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NEONATAL INTENSIVE CARE PATIENT CLASSIFICATION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled

NEONATAL INTENSIVE CARE PATIENT
CLASSIFICATION

submitted by NICOLE BERTINSHAW
in partial fulfillment of the requirements for the degree of Master of Health Services Administration.

DEDICATION

To Ross, for showing unbounded patience and understanding, for giving me his love and support, and for believing in me.

ABSTRACT

The purpose of this research project was to develop and validate an assessment and classification procedure adapted to the special needs of neonatal intensive care patients. These patients were categorized into the three levels of care recognized by the American Academy of Pediatrics as continuing or convalescent, intermediate, and intensive care. The study was undertaken in response to the expressed need for such an instrument by the regional tertiary care center in Southern Alberta.

Operational definitions of the three levels of care were developed through the Delphi technique by a multi-disciplinary panel of eleven experts in the ICN setting. Consensus of opinion on the criteria for belonging to each of the three classes was obtained after three rounds of deliberation. An assessment form was constructed on the basis of a review of related literature and consultation with various ICN health practitioners, most of whom were not part of the Delphi panel. This was pre-tested for item reliability and was found adequate.

The assessment form thus developed was then used to collect data on a sample of ICN patients from six hospitals in Southern Alberta over a period of three weeks. Every infant present in the participating hospitals at the start of the survey, or admitted during the three weed period, was assessed. Each infant assessed was also assigned to one of the three levels by the nurse-assessor at each institution. The completed assessment forms for the 138 patients thus sampled were distributed to each Delphi panel member for

classification. Information on the identity, placement, or assessor classification was not provided to the Delphi participants.

The mean and the mode of the eleven subjective classifications thus obtained for each patient were determined and used as the criterion measure for further analysis by multiple regression and discriminant analysis respectively. Based on the data collected and the criterion measure assigned to each patient, the statistical models enabled selection of those assessment variables which were most powerful in predicting level of care required.

Both sets of predictive variables were tested for predictive validity by comparing the subjective criterion measure (mean or mode) with the objective classification (obtained through multiple regression or discriminant analysis) resulting in self-hit rates or 88.4 and 89.1 percent respectively. A modified jackknife technique was also applied using rotating subsets of 10 percent for multiple regression and 5 percent for discriminant analysis yielding cross-hit rates of 82.6 and 83.3 percent respectively. This indicated that the classification procedures being used had an adequate degree of validity.

The relative simplicity of the multiple regression model led to its selection over the discriminant analysis model as the prediction equation to be used for patient classification. A classification procedure based on this model was developed and described. A serious limitation was encountered in the attempt to develop a comprehensive instrument when it was found that parental needs for support and teaching could not be consistently assessed by ICN nursing staff. Recommendations for further research were made with emphasis placed on incorporation of parental needs and on rendering the proposed instrument more practical.

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CHAPTER I

INTRODUCTION

The health service system is becoming increasingly complex as specialization, public involvement and developments in technology augment. Institutions in the system provide different types and levels of care to a great variety of patients and employ a wide spectrum of manpower. Simultaneously, economic constraints are multiplying and these institutions must adapt to limited resources and growing demands for service. In 1973, the Department of National Health and Welfare established a committee to conduct a study on patient care classification in order to develop guidelines for provincial and institutional health services systems. This committee identified the goal of a Health and Social Program in _The (1973) Report of the Working Party on Patient Care Classification to the Advisory Committee on Hospital Insurance and Diagnostic Services_, hereafter referred to as the Working Party Report.

> The ideal goal of a Health and Social Program is to have the _client_ or the _patient_ in the _right place_ with the appropriate service at the _right time_. In order to achieve this ideal the program should have the capacity to a) _Identify the needs_ of the individual; b) _Identify the time_ when the services will have optimal benefit; and c) _Identify the place and means_ through which the needs would be met by the appropriate service (Working Party Report,1973,p.6).

Nursing as the largest single manpower group in the health services system, has felt the growing pressures to increase the efficiency and effectiveness of rendered care

more than any other group. Early industrial engineering studies of the nursing function led to one viable approach which was the development of patient classification systems through the assessment of patients based on their nursing care requirements. Consequently, the concept of patient classification has traditionally referred to the assignment of patients to categories based solely on nursing care needs in a given setting. As such, patient classification by levels of care is an aid in providing the sort of information necessary to match nursing resources with patient requirements.

Ideally, however, what is required is a tool which encompasses the total care needs of the patient, thus yielding the kind of information needed to provide a basis for balancing medical, nursing, social and other health care resources with patient requirements. The development of such an instrument could facilitate interdisciplinary communication within an institution since the tool would encompass the needs of the patient in terms of each health care discipline. Further, this instrument could enable exchange of information on a standardized basis among institutions thereby increasing understanding and cooperation.

1.1 Objectives of the Study

This study is an attempt to develop and validate a classification instrument specific to the total care needs of intensive care nursery (ICN) patients, aimed at categorizing patients in terms of the three classes (continuing or convalescent, intermediate and intensive) which are recognized at present in various pediatric units, in accordance with the standards and recommendations of the American Academy of Pediatrics (1977). That classification is based

on information regarding the infants' need for medical, nursing, para-medical and non-medical care. This information is recorded on an assessment form which is filled out by the responsible nurse in consultation with the physician and others involved in the care of the patient. Classification criteria are based on the judgement of a professional multidisciplinary panel of experts using the definitions for each level of care provided by the American Academy of Pediatrics, as modified by this panel. The ends to which such a system could be used focus on the question of facilitating communication among professionals, both intra- and inter-ICN, in order to better match available resources with patient needs. The need to establish levels of patient care for infants has been identified by the community of hospitals in Southern Alberta as an urgent one (Haslam, 1978). At the inter-hospital level, the development of criteria for the classification of sick infants will facilitate the transfer of babies into and from different levels of intensive care nurseries. Such a tool would allow objective standardized assessment of infants on the basis of their total care needs by nurses and physicians in different participating institutions.

At the intra-professional level, a valid and objective classification instrument would allow easy documentation of the acuity of illness of patients and their corresponding needs in terms of resources. Classification of patients would allow ICNs to determine capacity in terms of available resources relative to the acuity of illness and number of patients.

The objective of this study is to develop an instrument which will be useful as an assessment and classification tool for the various ICNs of Southern Alberta. More specifically, the emphasis of the study is to:

(1) develop a classification procedure for ICN patients

based on standardized criteria of a multidisciplinary nature; and (2) validate the classification procedure thus developed.

1.2 Statement of the Problem

In recent years, there has been a marked trend in provincial government to control the annual increase in the operating budget for all services which it funds, including health care. Due to the combined effects of inflation, technological advancement and population growth, this has resulted in decreased purchasing power for the institutions, relative to expressed need or demand. Simultaneously, the technology available to intensive care nurseries has increased and has resulted in more infants surviving, some of whom would have died had they been born only a few years ago. Many such contextual considerations have led to an acceptance of the concept of regionalization, which involves the sharing of available resources, as a viable alternative for the ICN network in Southern Alberta.

For some time, concerned physicians, nurses and administrators in Southern Alberta have recognized the need for increased collaboration in the delivery of services to high-risk infants. One of the hospitals was designated, by the Government of Alberta, as the tertiary level care center for the region of Southern Alberta and funds were made available for its development as such. Partly as a result of this, and partly as a result of limited ICN resources in other areas, the number of babies referred to the tertiary center has increased dramatically over the past four years. Although many of these infants do require tertiary care, the care requirements of many others could be met in less complex, secondary centers.

This situation has led to two major problems. The first is that as the tertiary center is often filled above capacity, staff and equipment resources may be stretched beyond safety limits. The second is that as the tertiary center receives more and more of the high-risk infant patients, the designated secondary centers fail to maintain the required skills. The solutions to these problems are complex and involve intricate teamwork both at the intra- and inter-ICN levels. An essential part of the solution rests in the development of an instrument which can objectively identify infants according to their needs for continuing, intermediate or intensive care.

The establishment of such a screening device would allow the proper identification of patients requiring transfer to another level of care and, further, would provide justification for hospital resource requirements, such as nursing manpower. A valid classification instrument, associated with a regional triage policy for ICNs could therefore lead to a better match between available resources and patient care requirements.

1.3 Significance of the Study

Many patient classification systems have been developed over the past three decades. A thorough historical overview of the developments in patient classification is summarized by Giovanetti into three phases.

> The first phase represented the period devoted to the search for the appropriate proportion of professional to non-professional nursing staff, a search that became critical during a period of nursing shortage and a heavy influx of many levels of nursing personnel. The second phase assumed a broader context to involve all members of the health care team. Rising costs and hospital bed shortages stimulated a conscious effort

> to ensure the proper use of resources. The concept and procedures of progressive patient care offered some assurance in placing patients in the appropriate facilities. The third phase once again focussed on nursing... A more detailed look at patient-days led to the categorization of patients according to their anticipated requirements for nursing care (Giovanetti, 1978,p.28).

Since 1960, when Connor's work at Johns Hopkins University Hospital was first published, the emphasis in most ensuing patient classification systems has been on medical and surgical patients. The classification by levels of care tended to be useful only to the institution in which they were developed, tended to look exclusively at nursing care requirements, and tended to be validated using care rendered rather than care required. The Federal Working Party Report on Patient Care Classification has recommended that further work be carried out to develop patient classification systems in all care settings, including intensive care and newborn nurseries. In that report, the need for a universally acceptable instrument is emphasized and it is implied that one beginning step toward the goal would be the development of instruments universally acceptable for subsystems in health care.

The development of a classification tool for neonatal intensive care patients was undertaken in the present study both in response to expressed need for such an instrument on a regional basis in Southern Alberta, and in keeping with the Working Party Report recommendations cited above.

A classification instrument based solely on nursing care requirements would be of limited validity, particularly if it is to be used in more than one institution. This is due to the fact that nursing practice is not defined on a universal basis but rather differs according to the characteristics of the institution. In order to

overcome institutional differences, a regional classification system must be based on patient needs for total care, which are universal. Keeping this in mind, one alternative is to go back to the once popular concept of progressive patient care (PPC) which involves all members of the health care team, described by Giovanetti as the second phase in the development of patient classification by levels of care.

This study is, in effect, an attempt to revive the PPC concept on the basis of total care needs including those other than physical needs, such as psycho-social and teaching. In the case of newborn infants, the social and teaching needs are not aimed at the infants, but at their parents, who must fulfill the infant's needs once he/she is out of hospital. Because the classification developed here is based on the patient's total care needs, it is necessarily multidisciplinary in nature as no one discipline can provide total care services. Since it is imperative that such instruments be used and interpreted uniformly in an entire hospital region, reliability of classification tools will be enhanced through the use of 'factor evaluation' rather than 'prototype evaluation' (Giovanetti,1975). The two types of evaluation for classification instruments differ in the actual design of the instrument. Prototype evaluations are characterized by broad descriptions and characteristics of the patient in each category, whereas factor evaluation involves the delineation of specific elements of care for which each indiviual is rated independently. Factor evaluation tends to make the assessment and classification a little less subjective in nature.

In summary, the significance of this study to the area of patient classification is that it is a multidisciplinary objective instrument, centered on the needs of the patient for total care.

1.4 Definitions

Central to any research effort is a clear understanding of the meaning of the key terms and concepts. The following are the definitions for concepts used in this thesis:

(1) ICN - an Intensive Care Nursery is the area designated in the hospital in which a newborn infant is placed when he/she requires specialized nursing, medical and/or ancillary services to meet his/her immediate physical requirements. This area is physically separate from the normal newborn nursery.

(2) Intervention - an intervention is a direct service required by individual patient, involving staff and/or equipment resources. These include both those services and resources needed in the provision of care and those required in the process of diagnosis (Chagnon,1975).

(3) Assessment - a determination of need for services on each individual patient, in terms of required interventions, and a recording of this information on designated forms.

(4) Classification - an arrangement of infant patients into groups indicating level (or intensity) of care, on the basis of assessment information. Each group has distinquishing needs for care services which are inferred through observable interventions. Classification also refers to the process of identification which refers to the assignment of a given patient to the correct class (or group or level) once such classes have been established by prior classification.

(5) Reliability - the degree of accuracy, stability or reproducibility obtained in any given measurement instrument. If two sets of data, collected by two individuals independently on the same subjects in the same circumstances, yield highly consistent results, an instrument can be said to be reliable.

(6) Validity - the degree to which an instrument measures that characteristic or condition which it aims or purports to measure.

1.5 Format of the Thesis

The study is presented in four main parts which are: Chapter II, a review of the pertinent literature; Chapter III, a presentation of the methodology used for the present research; Chapter IV, a presentation of the results and an analysis of these; and Chapter V, a brief discussion of conclusions and recommendations based on the findings of this research study.

CHAPTER II

OPERATIONS RESEARCH AND PATIENT CLASSIFICATION: A SELECTIVE REVIEW OF THE LITERATURE

The intent of this chapter is to present an overview of the development and trends in (1) the process and implementation of operations research and systems analysis in health services, (2) patient classification systems, approaches, and methodologies, and (3) the nature and organization of neonatal intensive care.

2.1 Theoretical Framework - Patient Need Assessment

A health service system, like any other system, has a purpose. Its purpose is to respond to the health care needs of a population. In order to achieve this objective, the administrators or health planners must have access to information regarding the supply of and demand for the services and resources which are required, in other words, they must be able to assess need and determine the appropriate response or action. Health care requirements for services and resources should be based on each individual patient as the needs of different patients may vary widely in quantity and scope. Because of this, although the viewpoint of the administrators focus on aggregated needs expressed for services and resources, these must be assessed on an individual basis.

Donabedian defines 'need' in terms of states of health

or illness viewed by the patient, the physician or both, as likely to make demands on the health care system. However, 'need' is also used to denote the services required in any particular situation or the resources required to produce these services.

> The concept of need, then, has been applied to (a) states of health or ill-health, (b) use of services and (c) levels of supply (Donabedian,1973,p.65).

This is recognized as a semantic problem and a concept of 'need equivalence' is proposed.

> Under this proposal the work 'need' would be reserved to describe states of the client that create a requirement for care and therefore represent a 'service-requirement potential'...Similarly, a particular bundle of services can be translated either into its capacity to satisfy need or into the resources required to produce that bundle of services. Finally, a given set of resources has its equivalent in the services that they can produce and the needs that they can satisfy (Donabedian,1973,p.65).

Starting then from the basis of the health care needs of an individual, one of the roles of the health care practitioner is to determine the services which correspond to the perceived needs. In his development of a patient classification system for use in pediatrics, Tilquin notes:

> ...what is determinant in considering the problem of allocation and planning of resources, is not the individual's health/social state and evolution, but the diagnosed health/social state, because it is the latter that constitutes the key to prescription of services (Tilquin,1978,p.8).

In essence, although 'need' <u>as perceived</u> by the health practitioner may not be exactly equivalent to <u>actual</u> 'need' it is often the only measure of need which is available. Once the services required have been determined by the

health care practitioner, it is the role of the administrator to assess the resource requirements associated with these services.

To the practitioners, the individual patient is a special case, with his own particular needs. The services which are available for therapeutic use, however, are limited in variety. In a similar manner, the variety of resources which can be utilized to fulfill the service requirements are also limited. This development of Donabedian's model leads to the concept of service requirement profiles.

> Thus, each service region is characterized by a service requirement profile (SRP) which is a list of all service elements required by individuals whose [health needs] are sufficiently similar for it to be, technologically, no longer possible to distinquish between them at the time of prescription (Tilquin,1978, p.9).

In this manner, a classification system is developed in terms of services needed on the basis of assessment of the patient's needs.

The pertinence of the above concept is emphasized by Kraegel and others who claim that the discrepancy between the ideas of the hospital organization and the actual process of delivering care is caused by an inability to identify and acknowledge the primacy of the needs of the patient (Kraegel,Schmidt,Shukla,& Goldsmith,1972). This inability is caused by the tendency of each professional group within the hospital to solve patient problems in terms of its own services, with little regard for the effect of these on other services. This is a reflection both of the subjectivity of professional judgement and of the limited capability for measurement of total patient needs by any one group.

A system of patient care was developed by Kraegel et al. on the basis of response by the organization to patient based requirements.

> If we are ever to develop an effective approach to health care, it is our belief that that approach must stem from man's basic physical and socio-psychologic needs (Kraegel et al.,1972,p.259).

A trend appears to be developing toward focussing research in health care on the basis of the patient's individual needs rather than on organizational function. In a discussion of the future operations research in patient aspects, King states that the "theoretical framework that should be used for research places the patient at the center of the system, and all decisions within the system use the patient state as a major criterion for effectiveness of the system" (King,1975,p.14).

In order to overcome the problems associated with measurement of patient need, due to increasing complexity and diversity, the scientific approach is an absolute necessity. In the health care field, operations research can provide this approach.

2.2 Operations Research

Operations research was first coined as a term descriptive of a new science during the Second World War. At that time, it referred to the study of military operations using scientific methods aimed at improving efficiency. As the body of knowledge grew as well as the scope of applications, it acquired many different names such as 'management science,' 'cost-effectiveness analysis,' 'systems engineering,' 'decision analysis,' and 'systems analysis.' Quade, however, points out that there is a definite diff-

erence between systems analysis and operations research in that the former is to the latter as strategy is to tactics (1968). This point is emphasized further by Hitch who states that whereas operations research dealt with simple problems with few variables and obvious criteria, systems analysis was used for problems of immensely greater difficulty and complexity with explicit treatment of and a great increase in the number of the interdependent factors considered (1973).

Operations research has as many definitions as it does applications. It has been defined as the "study of man-machine systems that have a purpose...[and]involves the application of physical, biological, and social sciences in the most quantitative way possible" (Page,1967,p.8). A different perspective is evidenced by Warner who defines operations research as a "powerful and effective approach for solving critically real management problems...[and whose] primary focus is on decision making" (1969,p.4).

As with any discipline, the operations research approach has distinquishing characteristics. The four main ones identified by Warner are:

(1) a primary focus on decision making;
(2) an appraisal resting on economic effectiveness criteria;
(3) reliance on a formal mathematical model; and
(4) dependence on an electronic computer (1967,p.6).

Page claims that the unique characteristic of operations research is that its success depends on taking <u>all significant factors</u> into account, thus distinquishing itself from the various branches of engineering and other bounded disciplines, which consider only the factors relevant to their field. For this reason, he continues, operations research is often undertaken by <u>teams</u> of specialists from

various disciplines (1967).

In the three decades which have passed since operations research was first recognized as a distinct method of analysis in military studies, this approach to decision making has become very popular in business, industry, and to a certain extent, in the public sector. Typical applications of operations research in industrial settings are production scheduling, inventory control, forecasting, and quality control (Schumacher,& Smith,1976). The public sector is claimed to have had less success in the use of operations research and Warner attributes this to two characteristics. One is that the public sector tends to lack clear-cut objective functions to be optimized as there is an absence of performance measures. The other characteristic is that whereas in industry, lines of authority and responsibiltiy for decision making are generally well established, in government the whole procedure is much more complex (1969,p.27). Areas of the public sector in which operations research has been successfully utilized are the Postal service, air traffic control, and national defense (Flagle,1967; Page,1967). The objective of these activities has been "the application of scientific method to the study of the complex operations carried out by these organizations and, ultimately, through such studies, to provide administrators and executives with a quantitative basis for making decisions" (Horvath,1964,p.779).

2.2.1 Operations Research in Health Care

The introduction of operations research into the health field has been, at least in part, in response to the increasing complexity of the administrative function. Gue traces this phenomenon to the period following the industrial revolution, when the division of manual labour

in industry was followed by a division of managerial labour. Because of the ensuing managerial segmentation, Gue continues, new problems arose concerning control and decision making. As a result,

> ...in the late forties and early fifties operations research was born in response to the need to handle some of these new and complex problems in industry and the military, and that the health field is just beginning its parallel development of O.R. and its application to complex problems of coordination and control (Gue,1965,p.7).

The three major roots of operations research in health services have been identified by Flagle as stochastic systems, decision processes, and work studies (1967). The observation that the flow of patients through the hospital wards was characteristically a stochastic process led to studies resulting in patient classification schemes of various types.

> These studies of wards and clinics and analyses of the probabilistic aspects led to some notions of organizational design and administrative processes. The motivation for a new synthesis was not to achieve some optimum, but to design an operating system compatible with the nature of the load placed on it (Flagle,1967, p.37).

The second major origin of operations research in health services came about through the study of decision-making in the processes of screening, diagnosis, and therapy. The difficulties encountered by physicians in these processes led to the development of formal decision analyses techniques specifically for health services. The third major root of operations research and the most influential in the development of patient classification systems was the industrial engineering technique employed in work studies. The importance of work studies in the health field stems mainly from the fact that this industry has very little labour

saving technology to draw on (Flagle,1967).

The amount of research effort in the operations research community in health has increased exponentially since the early 1960's (Young,1975). In 1976, Fries listed a bibliography of operations research in health care systems comprising 188 entries. At this time he claimed that more articles had been published in the last four years than in the two decades preceeding it (Fries,1976). As well as increasing in volume, operations research has also increased in scope of applications. Initially applications were predominantly concerned with systems within hospitals, such as staffing, appointment systems, hosptial inventories, and blood banking (Fries,1976;Stimson,&Stimson,1972). More recently, studies have started to consider other aspects of health care deliveries, such as regional planning, health status indices and forecasting demand (Fanshel,& Bush,1970; Shuman,Wolfe,& Speas,1974; Thomas,1968).

As the volume and extent of operations research expanded with time, the techniques available to researchers also increased in number and complexity. Whereas early practitioners were fundamentally interested in the work activities of people and in the relationships between people and machines, more recently researchers have begun to realize that they should look at all system characteristics (Goldman,1975). This led to an evolution in the focus of operations research from subsytem to 'total' system thus becoming in effect systems analysis. As the perspective of the operations researcher broadened, he began to think of this as the 'systems approach' where his chief interest was in characterizing the nature of the system in such a way that the decision making could take place in a logical and coherent fashion (Churchman,1968,p.x).

Despite the great volume of operations research work

carried out in health services, Young notes that a growing uneasiness is evident among the O.R. community (1975). This feeling stems from the belief that operations research is not realizing its full potential. The major reasons cited for the difficulties encountered in the implementation of operations research work are:

(1) studies are often too theoretical or academic and have little to offer the decision maker with a real problem;
(2) there is a tendency, on the part of the researcher, to view the hospital as a mechanistic and seperable system, often disregarding human behaviour and subsystem inter-relationships;
(3) there is inadequate communication between the researcher and the decision maker;
(4) there is an abdication of responsibility for implementation such that once the model is developed, the researcher does not concern himself with the realities of its implementation and use;
(5) omission of the medical staff or patient from hospital studies;
(6) failure to recognize the limitations on the power of the administrator;
(7) failure to assess the impact of introducing computer technology to the hospital;
(8) omission of key variables that are difficult to quantify ; and
(9) failure to include detailed information on the benefits and costs of the proposed changes (Stimson,& Stimson, 1972; Young,1975).

An optimistic note is provided by Flagle regarding the future of operations research in the health field.

> However, as some of the substance of operations research has found its way into training programs for hospital and health services administrators, and as

> training in operations research has become increasingly available in schools with adjunct medical facilities, one sees a return to direct attacks on significant problems of the health services. Yesterday's language barrier between researchers and administrators diminishes steadily (1975,p.84).

2.3 Patient Classification Systems

Early operations researchers in health care concentrated on improving the efficiency of resource use through techniques borrowed from industrial engineering. Work studies on nursing service led to the need for a work measure which in turn led to the classification of patients according to their needs for nursing care. In this manner, patient classification became an essential step in operations research on staffing and resource scheduling problems.

Classification has been defined as "systematic arrangement in groups or categories according to established criteria" (Webster's,1977,p.206). The three purposes of classification which are applicable to most sciences are

> ...economy of memory...without the ability to summarize information and attach a convenient label to it we would be unable to communicate....
> ...ease of retrieval of information from a classificatory system....
> ...to describe the structure and relationship of the constituent objects and to simplify these relationships in such a way that general statements can be made about classes of objects.... (Sokal,1974,p.1116).

The diversity of patient and patient needs in the health care system make a classification scheme responsive to these differences essential for rational management of the available resources.

The issues and trends in the health service delivery system not only give evidence of the urgency of maximizing the efficiency of staff resources but also indicate that better use of health services of all types is necessary. In the health care system, the classification of patients is being perceived, with growing importance, as a vital step in resolving the problem of resource allocation.

Identification of the patient's needs is of prime importance in patient classification. These needs can vary widely among patients and must be met by a variety of health resources. Historically, nursing resources have been the focus of patient classification systems, largely because of their relative importance in total institutional costs. As such, the primary purpose of patient classification was to respond to the variable nature of the demand for nursing care (Giovanetti,1978).

A review of the different approaches to patient classification from a methodological perspective provides a framework for the understanding of present day systems.

2.3.1 Classification by Levels of Care

Classification by levels of care generally refers to the grouping of patients on the basis of levels of nursing care required. Although no one classification system has been adopted universally, the majority are based, to a certain degree, on a prototype model developed by the Operations Research Group at Johns Hopkins University in 1960.

Johns Hopkins Operations Research Group

A patient classification system was developed by the Hopkins group as part of a study directed toward "problems

of matching personnel resources, particulary nursing, to patient needs" (Connors,1961,p.30). This match was approached through the development of a Direct Care Index which was used as a daily measure of patient needs.

A work measurement study was undertaken in which nurses were observed performing direct care. The patients selected for observations were stratified according to sex, service (medical, surgical or opthalmological) and their 'condition'. The patient's condition was described in terms of level of need in the following areas of nursing care:
(1) mobility;
(2) state of consciousness;
(3) emotional state;
(4) adequacy of vision; and
(5) need for isolation.
An important observation was made when it was found that, among the areas of nursing care listed above, there were predominant combinations of level of need. It was also noted that these predominant combinations were significantly different from each other in the amount of nursing care time required by patients. An important development in patient classification was reached at this point. As Connor states:

> This suggested the possibility of a numerical scale of degree of nursing need, one that would be an expression of the amount of care required in terms of the patients' observable characteristics (1961,p.33).

As a result of these preliminary observations, a hospital-wide system of patient classification was developed. The first step was to design a detailed patient condition questionnaire which was to be completed by the head nurse of each ward. This first format was found to be too time-consuming and met with opposition by user-nurses. A shorter, revised version was finally produced which, it

was claimed, could accurately be completed for a 29-bed ward in just five minutes. The three-category system instrument contained a variety of information relating to the patient's degree of self-sufficiency with regard to his own care. The areas of patient need were listed as:

(1) ambulatory;
(2) up in chair;
(3) bathing;
(4) feeding;
(5) miscellaneous therapy; and
(6) emotional status.

No justification for the choice of items on the questionnaire was presented. Once this assessment form was completed by the head nurse, each patient was assigned to one of the three categories as determined by a set of specific classification criteria previously defined. The basis for these decision rules was not given. The categorization system was tested for validity through further work measurement studies. This work was claimed to verify the original conclusions on the amount of nursing time required for patients in each class. If the aim of this classification procedure was to classify patients according to care rendered, then this method of validity testing was appropriate. On the other hand, if the resulting instrument was purported to classify patients by care required , work measurements can only indicate care rendered and can therefore not be considered adequate as tests of validity.

The significance of the Johns Hopkins study rests on its findings that:

(1) the total hours spent by nurses with patients varies greatly;
(2) the principal determinant of workload is the number of critically ill patients;
(3) the number of critically ill patients on any general acute care ward is usually determined by chance; and

(4) the technique of classification of patients can be used to determine workload.

Although findings 1,2, and 3 were all fairly self-evident and expected, this was the first time that these assumptions had been investigated.

Deer Lodge Hospital - MacDonell & Murray

Another patient classification system was developed by MacDonell at Deer Lodge, Winnipeg, Manitoba. The purpose of this study was to modify "morbidity and mortality data to show the type of patient being cared for in Department of Veteran Affairs Hospitals across Canada" (MacDonell,1965, p.499). Perhaps because the initial aim of the study was not for staffing purposes, an approach different from that of the Hopkins group was taken.

This classification study started with the development of a questionnaire which was made up of items grouped under the following headings:

(1) clinical monitoring;
(2) technical nursing;
(3) non-technical nursing;
(4) physical medicine; and
(5) organized psychiatric unit.

The items listed under each of these headings had been selected as those which appeared to best indicate nursing effort. No explanation of this selection process is provided in the literature. This preliminary questionnaire was completed for each patient by the investigator, with the simultaneous assignment of each patient to a care category, according to prototype definitions previously established. The questionnaires were then analysed, by an unspecified technique, to determine the items of direct patient care which characterized each care category. A numerical score

was assigned to each item on the questionnaire, based on the amount of effort involved. There is no explanation of how this amount of effort was determined.

> Then, knowing the characteristics permitting identification of the Care Categories within each Level of Care, it was possible, by data processing methods utilizing arbitrarily selected numerical values, to produce a classification of patients according to Level of Care (MacDonell,& Murray,1965,p.504).

It is not clear how the quantification of the characteristics was achieved and how these were linked to the levels of care.

The significance of this study lies in its attempt to develop a classification of patients that is less dependent on observer judgement, and therefore more objective, than Connor's. The scope and number of items included in the assessment form is much larger in the MacDonell study. One influencing factor could have been the probable long-term nature of care provided in these hospitals. As well, decision rules were based on factor evaluation, rather than prototype as was the case with the Hopkins work. The use of data processing techniques mentioned by MacDonell reflects an attempt to achieve objectivity and comprehensiveness in the Deer Lodge study. The reliability of this assessment/classification procedure was not reported, but an effort was made to teach all assessors how to use the form in a uniform manner. As well, since no observer judgements were required, it is likely that the form did have considerable reliability. The information obtained by the data processing method was cross-checked with that obtained by the personal, subjective classification made at the time of assessment. It was claimed that this test established the validity of the data processing method.

<u>Hospital Systems Study Group (HSSG), Saskatchewan</u>

As part of a long-term study of hospital organization, the Hospital Systems Study Group undertook the development of a patient classification system (Holmlund,1967). Previously existing schemes such as the ones reviewed above were examined by this group but were deemed unacceptable to nursing staff at the Saskatchewan University Hospital.

The development of the HSSG classification system began with the drawing up of a lengthy list of patient variables and other factors. These were grouped under the broad headings:
(1) general vital statistics;
(2) room facilities;
(3) physical attachments;
(4) monitoring and observation;
(5) ambulation;
(6) personal care; and
(7) nutrition.

A project nurse completed the assessment form for each patient and, independently, the head nurse also assigned the patient to one of five categories according to prototype definitions. It was found that the five-level form was too cumbersome and it was replaced by a simpler three-level form. No explantion is given as to why or how this reduction was accomplished. A comparison of the head nurse's evaluation (on a five-level basis) with the three level form results was carried out. It was found that disagreement on individual patients was less than 10 percent. A template system was devised to make the system more workable when used to evaluate all patients on a ward simultaneously. An attempt to validate this classification scheme was undertaken (Sjobert,& Bicknell,1968). A high correlation between the HSSG results, the head nurses' evaluations

and the MacDonell system was interpreted to mean that the HSSG system was valid. This is a misleading assumption to make as this comparison reflects a degree of reliability but proves very little about whether or not any of these classification schemes actually measure what they purport to measure.

Although the introduction to the HSSG study claims that the needs of the patient must be the focus of any patient classification scheme, its focus is strongly management-oriented rather than patient-oriented. This study added little to the body of knowledge regarding patient classification; however it should be noted that it is widely employed (Reeve,& Dawes,1974) as a useful system, with its main advantage being that it is a quick and simple method of classifying patients.

The significance of the above study lies in its simplicity. In acute care settings the stochastic nature of patient states gives rise to sudden changes in patient needs. If the objective of a patient classification system is to keep track of the patient's needs in a dynamic way, the tool developed <u>must</u> be quick and simple to use. The danger inherent in such systems is over-simplification which, if not guarded against, could jeopardize validity. It is important to keep in mind that for prototype classification systems such as this one, since levels of care are relative to the hospital in which they were developed, generalizability to other institutions is always a problem.

<u>Hamilton Civic Hospitals</u>

A study was undertaken by a research group within the Hamilton Civic Hospitals organization to develop categories that indicate patient needs for nursing care (Key,1971).

Two methods were used to arrive at the patient category; one was objective, the use of the patient classification procedure which was the aim of the study, and the other was the subjective evaluation of the head nurse. The study proceeded in three major steps which were the development of a preliminary categorization step, a trial test and a final test. An initial survey conducted on head nurses revealed that a five-level classification would be most appropriate. This survey also yielded 150 nursing procedures which were eventually grouped into seven areas of patient need. These areas of need were:

(1) physical or hygienic;
(2) physical observations;
(3) medications;
(4) treatments and dressings;
(5) instructional needs;
(6) diagnostic and therapeutic needs; and
(7) behavioral observation and support.

The research group worked on each individual area of need listed above to determine five levels of intensity within each one. A value of one to five points was thus attributable to each area, depending on the intensity of care required by the patient in that area of need. Class limits were defined by comparing the subjective evaluation by the head nurses according to prototype definitions and the total number of points assigned to each patient according to the assessment form. Class limits were thus constructed in terms of total points.

This study is one of the first in which the system is useful to the entire range of patients, from intensive to rehabilitative care. An interesting detachment from utility in staff resource allocation is noted, with an associated emphasis on comprehensiveness and intensity of care, and de-emphasis of timing values for various procedures. Another

significant aspect of this study is the inclusion of the behavioral and support aspects, as well as instructional needs of the patient, which are given equal value to any other, more 'traditional' , physical aspect of care. These two areas of patient need were largely omitted in other studies. A major weakness in this study is that the points assigned to each area of care were largely subjective in nature, and no empirical basis was referred to for the assignment of these values. No validation procedures or testing were reported in this research report.

Project IRODOM[1] , Ste.Justine Hospital, Montreal

As part of a four year project, the global objective of which was to develop a computerized nursing management and scheduling system based on the needs of pediatric patients, a patient classification scheme was devised at the Hopital Ste.Justine, Montreal, Quebec (Laberge-Nadeau,& Chagnon,1974).

Following initial unsuccessful attempts at developing a patient classification system, the IRODOM group tried a new approach. The new criteria were claimed to be based on fundamental human needs, rather than on nursing functions. These needs were divided into three broad categories; physical needs, psychological needs and specific needs such as therapy. The nursing procedures warranted by these needs were distributed among the five levels of care according to an estimation of the time required to carry them out. The special feature of the IRODOM classification was that it had two types of classification forms; a simplified form and a detailed one. The simplified form was useful in the classification of 85 percent of all pediatric patients. The

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criteria in this form were in their simplest possible expressions, with each criterion being a single factor. If several factors were applicable to a patient, the factor determining his class was the one denoting the highest class. Should classifying problems arise, recourse could always be made to the detailed form in which the criteria were accumulations of factors.

The significance of this particular study lies in its patient centered approach. Few classification systems work from the patient to the organization, yet most profess to respond to patient needs. One important finding in this study was that indirect care, which had been measured through work studies, varied as much as did direct care, and was often not negligible in quantity. The assumption that indirect care was a constant across levels of care and that the actual amount was small relative to direct care had been made in every other study, beginning with that of Connor.

PRN[2] 74 - Pediatric Classification System, Montreal

A group composed partly of the members from the defunct IRODOM study developed a patient classification system aimed at improving the IRODOM system (Chagnon,Audette,Lebrun,& Tilquin,1975).

A new methodology was adopted in order to overcome the problems inherent in the IRODOM system which were seen as:
(1) too much subjectivity; and
(2) measurement of care rendered, rather than care required.

The first step taken by the PRN 74 group was to draw up as complete a list as possible of all nursing interventions

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in pediatrics as these interventions were to act as factors in the classification scheme. Each intervention was then given a normative weight on the basis of an estimate of both direct and indirect care time required. This estimate was derived through the use of opinion polls on a group of experts. Using the normative weights attributed to each intervention, a sample of patients was assessed for total weight by summing the weights for each intervention required by each given individual. Patients in the sample were classified into four classes which were in effect a range of total weights which could be achieved by totalling the weights of the specified interventions for any given patient. This was the method used in the development of a scale (of level of care). The only guidelines in the choice of class limits and the number of classes were the normative judgements of nurses having some experience with pediatric patient classification systems.

The system was tested for inter-rater reliability and was found to yield an 84 percent agreement rate. Validity was tested by measuring the "degree of occupation" of nurses versus the classification of their patients. The degree of occupation was determined by observing which activities on a list of priorities (of duties which the nurses were to carry out at some time during the day) were being performed at certain times in the day, given the number and classes of patients present. This was thought to reflect the accuracy of the classification system in the prediction of patient needs in terms of available resources. Once again however, the validation of the classification procedure was based on care rendered or utilization of resources. The results obtained were inconclusive and validity was therefore not assured.

This classification system was innovative in two respects. One was that its construction was based on care re-

quired, determined through normative measurements. The second area of originality in this system is that it is strictly intervention-oriented, rather than being comprised of a mixture of different types of patient variables such as patient condition, location, age, and procedures required as was found in previous classification systems. The advantage of the intervention-orientation is that it eliminates the use of patient variables and other factors which:

(1) can be very vague indicators of the care required;

(2) are often duplicated by other factors at the time of assessment; and

(3) are sometimes difficult to define and quantify therefore leading to greater subjectivity of the instrument.

The disadvantages of the above classification system lie mainly in the area of utilization of the developed instrument. If the final instrument is to include all the interventions used in its construction, this would result in an extremely long assessment/classification tool, which would probably never be used by practitioners because of the time involved in this administrative duty. Further, because the instrument was developed at one highly specialized hospital for a particular population, it is unlikely that general hospitals would consider application of the same form to be appropriate for their populations. The important contribution of this study however, is that it provides a normative methodology which could be developed in other institutions.

2.3.2 Progressive Patient Care

The concept of patient classification on the basis of the patient's total care needs came to the fore in the early 1960's. This broader approach to classification was known as progressive patient care.

> The principal objective of this growing concept is to provide better treatment and care by organizing hospital services around the individual patient's medical and nursing needs. This can best be accompl-ished by setting up special nursing units to which patients are assigned in accordance with their degree of illness and need for care (Haldeman,1964,p.1).

One of the major initial studies in this area of classification was carried out by the U.S. Public Health Service at Manchester (Conn.) Memorial Hospital (Lockward,Giddings,& Thoms,1960). Three categories of patients were defined as (1) special care, (2) intermediate, and (3) self-service. Patients were placed in the appropriate unit on the basis of a check-list which included sixteen criteria. These had been selected for the evaluation form because of their assumed sensitivity to the needs of patients. The criteria consisted of certain therapeutic procedures and patient conditions (Haldeman,1964). An evaluation team was formed, consisting of medical and nursing staff, to determine the weight to be associated with each factor on the form. Weights were identified as; A-compelling, B-moderate, and C-contra-indicator. In this manner, a checkmark on the patient assessment form could then be compared to a template form and the appropriate placement (to a unit) could be determined (Flagle,Lockward,Moss,Strachan,& Haldeman,1964). No report is given of reliability or validity testing and it would appear that the greatest strength of this system is the involvement of both medical and nursing staff in its preparation, and its simplicity.

A different approach was taken by a study group in Halifax, Nova Scotia (Gordon,Wanklin,Harvey,& Hatcher,1966). The prototype evaluation approach was used to classify patients into one of six categories. These were intensive care, intermediate care, minimal care, long-term active care, nursing care, and sheltered care. Categorizations were made by medical residents for each patient using the proto-

type definitions. Independently, a questionnaire on each patient was completed by the investigators as a basis for categorization according to prototype definitions. It was claimed that the method developed was practical and feasible and, given a few modifications, could be utilized.

The basic difference between patient classification systems designed for progressive patient care and those designed for nursing staffing (levels of care) is that "the former consider the entire spectrum of patient requirements for services, while the latter relate only to requirements for nursing services" (Giovanetti,1978,p.23).

Few methodological developments have appeared recently on the progressive patient care concept; it seems, however, to be in common use, at least to a certain extent, in many hospitals (DeVries,1970;Fetter,& Thompson,1969).

2.3.3 Classification by Types of Care

As costs increase with demand for institutional and long-term care in acute care settings, mechanisms for placing patients in alternative, less expensive health care programs are receiving greater attention. The assessment of a population of chronic or ageing patients entails a more comprehensive effort than does the acute care population due to complexity associated with the long-term nature of patient needs. The objective of a system of patient classification by types of care (PCTC) is to assess the relevant characteristics of an individual patient and, using these characteristics, to categorize the patient. Once the patient has been classified, the most appropriate setting (in a variety of long-term programs) can be selected to most effectively meet his needs. The three essential steps of a classification/placement procedure are assessment of

patient characteristics and need, classification according to some definition of types, and a placement decision under the environmental constraints.

A User's Manual for patient classification in long-term care was published in 1974 by a research group from four American universities (Jones,1974). The conceptual framework of the classification system included two aspects; characteristics of the classification components and rationale for proposed format. It was claimed that the elements (factors) of the system had the characteristics of being patient-oriented, multi-dimensional, objective and relevant. The multi-level format was constructed to provide flexibility and multi-purpose use. The recognition that these element characteristics and multi-level format were important in developing an instrument provided new insight in the area of assessment. Although the document speaks of a classification procedure, there is in fact no categorization system presented for patients once they have been assessed.

In 1975, Kyle attempted to develop a patient classification system, based on the definitions of the five 'types' defined in the Federal Working Party Report. An assessment instrument based on the literature, expert opinion, and previous studies was constructed, and the patient characteristics and related needs listed on the form were the factors which determined the classification of the patient. The instrument was tested for reliability and validity using discriminant analysis and the Bayesian classification procedure, as well as an outside expert to determine patient classification on a subjective basis for comparison (Kyle, 1975). The strength of this research effort lay in the attempt which was made to correlate assessment variables with the classification by type of care using statistical modelling. The major weakness of Kyle's study consisted of lack of emphasis on the validity of the criterion measure,

as this measure was based on assessor judgement and was not rigorously tested.

The use of discriminant analysis was not original as it had been frequently used in previous studies on clinical decision making (Bay,& Flathman,1973; Hughes,Kalbfleisch, Brandt,& Costiloe,1963; Parker,& Boyd,1974). Parker, for example, used discriminant analysis in the development of a geriatric index for rating the level of health care need. Results indicated a hit rate of 70 percent on the basis of the 19 indicators used. This was considered inadequate to justify the assignment of a new patient to a given level of health care need. It was also found that differentiation between the categories was not always clear as some categories subsumed others (Parker,1971).

Further use of statistical methods was made by Parker and Boyd in a comparison of discriminant analysis versus clustering analysis of a patient classification for chronic disease care (1974). The discriminant analysis was found to be adequate to assign patients to the appropriate level of care but the cluster analysis, although showing a reasonably high degree of relationship to level of care, was more difficult to interpret. The interpretation of cluster analysis is largely dependent on the choice of similarity measure.

More recently, a research group at the University of Alberta has developed a patient classification system by types of care (Bay,Overton,Harrison,Stinson,& Hazlett,1979). A criterion team consisting of a physician, a nurse, and a social worker was used to assess and classify patients according to prototype definitions for each of the five classes. This classification was used as a criterion measure. Applying discriminant functions obtained from the study data and the Bayesian classification procedure, an objective and empirical classification tool was developed. Both

stepwise discriminant analysis and cluster analysis techniques were used to yield 'homogenized' classification measures. Despite the sophisticated statistical modelling carried out, it was found that a certain percentage of the sample population could not be neatly categorized into any one class. A predictive validity of 90 percent, as evaluated by the U-method (jackknife technique), was established after the resolution of some difficulties arising due to the inherent 'fuzziness' of the patient population. As a result, the research group developed the idea of types of care profiles which give the probability of a particular patient belonging to each one of the five classes. This work led the researchers to suggest that it may be unrealistic to expect measures of patient needs to comply with the mutually exclusive and exhaustive categories of patient classification.

The three concepts of patient assessment, classification and placement were clearly delineated in this report as distinct, separate, and sequential processes, whereas most previous studies had confounded these. A patient placement decision model was given using the types of care classification results. Although this study presented one of the most involved and rational methodological approaches to date, it may be some time before such a classification procedure is used routinely. It should be noted that this approach has yet to be tested. The assessment form is quite long and complicated, requiring up to 30 minutes for the assessor to complete for each patient. There is still also a logistical problem in the requirement of a centralized body to process all assessment/classification/placement procedures.

2.3.4 Issues and Limitations in Patient Classification

A number of issues and limitations have been identified in the field of patient classification. One of the dominant issues lies with the critical indicators of care. These are the variables included in the assessment which are most crucial to the correct classification of each patient. Critical indicators have often been criticized in various systems for their lack of comprehensiveness and their lack of attention to non-physical patient needs, such as instructional and psycho-social needs (Giovanetti,1978). The major reason for this omission in most classification systems is the great difficulty in measurement of such variables. Problems commonly associated with indicators of care are the imprecise definition of each one, leading to ambiquity and subjectivity on the part of the assessor, and the undetermined adequacy of the choice of indicators to correctly predict classification (Parker,1971). Sokal notes that cultural and personal biases affect character or indicator selection in virtually every field of classification (1974). This is not avoidable to a certain degree since in most patient classification systems, no generally acceptable criteria exist and the consensus of a group of individuals is needed to determine criteria. This is partly why Chagnon et al. stated their classification on the basis of a comprehensive list of interventions (1975). This tended to lessen the personal bias in the group as to which interventions were critical and which were not. The advent of discriminant analysis in classification schemes may reduce the problems of human judgement in choosing the indicators to be included on an assessment form.

The issue of validity of any classification system remains a strong concern as, to date, no instrument has demonstrated validity in terms of need (Giovanetti,1978). This may be related to the inherent limitations in patient

classification systems noted by Akpom et al. as difficulties in making value judgements (1973).

In classification by levels of care, the problem of quantification of nursing care time is generally an objective of the system. Although useful in predicting staff resource needs for the next day or shift, this approach is generally not useful for longer term predictions. As well, it tends to reflect and perpetuate existing nursing practice thus formalizing the status quo (Giovanetti,1978). Few classification systems make allowance for flexibility in practice and future change.

Patient classification systems are often interpreted by their users as decision making tools, rather than aids to decision making by professionals. This sometimes leads to the feeling among professional care-givers that classification instruments infringe on their professional judgement (Tilquin,1977). Classification builders must be cognizant of this if the instrument they develop is to be accepted.

2.3.5 Trends

As patient classification systems change and develop, a few trends can be observed. The increased dependence on electronic computers and sophisticated statistical models is a characteristic of classification studies in all sciences (Sokal,1974). This observed trend is partly due to the increasing complexity of classification schemes, with the growing tendency of researchers to make them multidimensional in an attempt to achieve comprehensiveness in their analysis (Akpom,Katz,& Densen,1973).

The advent of electronic computers has also allowed

the development of more objective instruments which are less reliant on human value judgements than were earlier schemes. Regionalization of services, which is evolving in response to resource constraints, has led to a growing awareness among researchers and administrators that classification systems must become standardized to enable use of a scheme in more than one institution (Giovanetti,1978). Recognition of this trend is given by Tilquin who emphasizes the importance of a normative, rather than empirical approach.

> Therefore two main characteristics that should be found in a new methodology for building up a classification are objectivity and normativeness. These two characteristics are not independent. It is impossible to obtain normativeness without first achieving objectivity (Tilquin,1977.p.28).

2.4 Analytical Techniques

The review of various approaches to patient classification presented above denotes a marked trend toward increased sophistication in the analytic techniques used. Among the many concepts and techniques available to health services research through operations research and systems analysis are three of crucial importance to the present study. These are discriminant analysis, decision analysis and the Delphi technique.

2.4.1 Discriminant Analysis and Bayesian Classification

Discriminant analysis is a multi-variate statistical method which can be used to distinguish membership of individuals. The distinction is made on the basis of a collection of discriminating variables that measure characteristics on which the groups are expected to differ.

The statistical objective of discriminant analysis is to weight and linearly combine the discriminating variables in such a way that the groups are forced to be as statistically distinct as possible (Nie,Hull,Jenkins,Steinbrenner,& Bent, 1975). Five assumptions are implicit in the use of discriminant analysis for classification purposes. These are:

1) The groups used are well defined in advance and are mutually exclusive and exhaustive of the population.
2) The assessment variables being used differentiate among groups and may serve as independent variables.
3) The prior probability of the individual belonging to each of the groups is known.
4) The discriminant scores are of a multi-variate normal distribution with a common dispersion, but there are distinct means for each group.
5) An individual to be classified is considered to be from the same population on which the functions are based (Bay et al.,1979,p.61).

Discriminant analysis has been one of the most frequently used statistical techniques in a wide range of studies aimed at classifying patients on the basis of diagnosis, prognosis, or symptoms. The success of these studies had led to the use of discriminant analysis in the making of decisions regarding the diagnosis of prognosis of specific diseases or conditions (Bouckaert,1971; Bay,& Flathman,1973; Hughes,Kalbfleisch,Brandt,& Costiloe,1963; Neurath,Einslein, & Mitchell,1969). Few studies have been reported on the use of discriminant analysis for the purpose of classification on the basis of the patient's need for care, whether it be nursing care or total care, however some work in this area has been done. In the field of long-term care, the assessment and classification of chronically ill or ageing patients has been carried out using discriminant analysis and the Bayesian procedure (Bay et al.,1979;Kyle,1975; Parker,& Boyd,1974). In acute care settings, discriminant analysis has not often been used as a method of classifying patients according to their total care needs. The full potential of discriminant analysis has not been realized due to the fact

that this form of classification has historically been based on a smaller number of variables than that for long-term patients.

One study was conducted in which discriminant analysis was used to categorize patients according to the severity of illness based on a 'Therapeutic Intervention Scoring System' (TISS) (Cullen,Ferrara,Gilbert,Briggs,& Walker,1977). The scoring system (TISS) used in this study disregarded the disease process causing illness, but looked instead at therapy required to maintain life and treat illness in critically ill patients. The criterion measure used was period of survival of the patient, an objective measure. Discriminant analysis was used to predict patient survival on the basis of information on interventions needed by the patient.

2.4.2 Decision Analysis

The decision making process, as seen by operations researchers, reflects an attempt at utility optimization in the choice of a possible course of action. Statistical methods are often used to analyze decision alternatives on the basis that statements of probability approximate a measure of uncertainty. In health care, the administrator and the health practitioner are frequently working under conditions of high uncertainty. A review of decision analysis by Bay et al. reveals that although attempts have been made to utilize decision theory in resolving therapeutic, diagnostic and screening problems, none had been directed to the resolution of patient placement decisions (1979,p.48).

One method commonly used in decision analysis is the Bayesian procedure. Application of Bayes' theorem to the results of discriminant analysis yields posterior probabil-

ities of any case/patient of belonging to a specified group. In diagnostic decision making, probabilities are defined in terms of diseases and/or sets of conditions or symptoms (Lincoln,& Parker,1967). As more information is collected on a patient, the probabilities of belonging to a defined group (diagnostic, prognostic, survival time, or intensity of care) associated with that individual also change, and a course of action is chosen accordingly. In the development of a classification for the the patient, the application of Bayes' theorem to the assessment information, using the results of discriminant analysis on a criterion data base, yields posterior probabilities of any given patient belonging to the defined groups. These probabilities can then be used by the decision maker to determine an optimal course of action, namely a placement decision. Application of decision theory to patient placement decision making has been suggested by Bay et al. (1979).

2.4.3 The Delphi[1] Technique

The Delphi technique was developed several years ago by the Rand Corporation as a method for obtaining a consensus of opinion on a particular matter from a group of experts. Consensus is obtained by eliciting and refining opinions from these experts.

> Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problem (Linstone,& Turoff,1975,p.3).

1 In Ancient Greece, Delphi was the site of a temple in which a deity revealed hidden knowledge or the divine purpose through an oracle (usually a priest or priestess).

The group used in the Delphi process is generally a highly specialized collection of individuals, chosen specifically for their knowledge and experience in the field under study. The issues examined in the Delphi technique are usually complex and thus obtaining exact knowledge is not possible. The two types of Delphi are; (1) conventional or technological, where an issue or problem is resolved through consensus of opinion among a homogeneous group of experts, and (2) policy, where the strongest possible opposing views are generated on the potential resolution of a major policy issue. The policy Delphi is not intended to generate a decision for the decision-maker, but rather to yield as complete a picture as possible of all the options. The policy Delphi could be potentially useful in achieving the following objectives.

(1) To ensure that all possible options have been put on the table for consideration.
(2) To estimate the impact and consequence of any particular option.
(3) To examine and estimate the acceptability of any particular option (Linstone,& Turoff,1975,p.87).

Policy Delphi would be useful for soliciting group opinions where the group membership is divergent and a multi-disciplinary approach is being sought. As such, this potential has significant implications for health care planning.

In the health field, the Delphi technique has been used extensively in forecasting, planning, and strategy formulation problems. In the area of classification, the Delphi has been used in the development of levels of care criteria and in the determination of indicator variable weight. For example, the Delphi technique was used to refine the levels of care criteria developed by Medicare (U.S.A.) as these were considered inadequate for determining whether or not a patient was being treated in the appropriate setting (Holloway,Holton,Goldberg,& Restuccia,1976). A group of

specially selected physicians in each of three hospitals was asked to generate and refine care criteria until a consensus aggregate was reached. Although evolved separately and independently, the three sets of criteria developed were remarkably similar. It was claimed that the study was successful in accomplishing its goal of establishing level-of-care criteria development. The authors felt that:

> ...these criteria are a significant improvement over the general levels-of-care framework of the Medicare criteria, because they provide the specificity necessary to make consistent decisions in concurrent UR (utilization review) . This ability to make consistent decisions based on good criteria, will make it easier for UR Committee physicians to defend difficult decisions to their peers or to fiscal intermediaries, and will provide a broader decision-making base than the Committee member's personal judgement (Holloway et al., 1976,p.70).

The Delphi technique was used in a more technological application in the development of a classification system for pediatric patients (Chagnon et al., 1977). The aim of this group was to achieve 'normativeness' in the allocation of weights to the various interventions possible in nursing practice.

> The weighting of interventions was obtained from a group of experts who determined by consensus the average time required for each intervention and its preparation and follow-up procedures under normal conditions (Chagnon et al.,1977,p.33).

The authors claim that this approach makes the instrument thus developed applicable for use in more than one hospital as no time measurements were used to develop it and the normative input originated from more than one institution. However, in this author's view, this conclusion is tenuous in view of the difficulty associated with subjective judgement and representativeness of the panel members.

The results can only be as good as the judgement of the panel members.

The Delphi technique has proved to be useful in many studies mainly because it has several advantages. These are: (1) reasoned opinions are expressed by individuals in the light of opinions expressed by associate experts; (2) personal biases and dominant personalities have limited influence on group consensus; and (3) time-consuming meetings and the need for a central location are avoided. The Delphi technique also has some disadvantages, some of which are: (1) the difficulty of designing a valid and reliable questionnaire for soliciting expert opinion; (2) the gradual consensus of opinion developed through several rounds may reflect conformity rather than increasing accuracy; (3) the process may also discourage divergent or minority opinions; and (4) assuring a valid and appropriate composition for the panel is difficult.

2.5 Patient Classification for Neonatal Intensive Care

In recent years, many innovations and advances in the technology of medical care, nursing care and medical research have enabled health care professionals to save a greater proportion of critically ill infants. In association with these new advances, neonatal intensive care units have developed in many hospitals. The main purpose of an intensive neonatal care area is to provide special measures of care through the concentration of specialized personnel and equipment to the high-risk infant (Pierog,& Ferrara, 1971). The measures of care which can be provided vary greatly from centre to centre. It is interesting to note that these centres, while providing measurable improvements in infant mortality rates, have been criticized on the basis that the measures of care carried out often have

iatrogenic effects (Hughes-Davies,1979; Yu,Hewson,& Hollingsworth,1979).

The need for highly skilled personnel from various medical and para-medical fields, as well as highly sophisticated life support and diagnostic equipment in these units, has necessitated the allocation of these scarce resources to designated referral centres. The development of regionalization in the United States and Canada is gaining momentum in relation to this trend (Graven,1977; Hardyment,1979).

Regionalization of perinatal services has been identified as one viable approach in resolving the problem of providing quality care on an equitable basis to an entire region.

> Regionalization provides a coordinated system of perinatal care for a defined population. By mutual agreement between the hospitals and physicians each hospital in the region identifies the degree of complexity of care it can provide to mothers and newborn infants, and patients are treated in the hospital best suited to handle their expected problems (American Academy of Pediatrics,1977,p.2).

A regionalized perinatal care system is responsible for the care of all newborns within a defined geographic area or population. Institutions operating within the region differ in their capability to provide the level of perinatal care required. When care requirements exceed the capability of the institution to provide the appropriate services, the patient is transferred to the nearest facility that has the required capability (Graven,1977).

In order to determine whether an institution has the capability to care for a specific patient, the needs of the patient for special services must be assessed. In order to rationally allocate the scarce resources within a region,

services should be rendered according to a set of criteria based on patient needs, such that patients are treated in the most appropriate facility for their level of need. A beginning step is then to produce a classification system or screening device with the objective of grouping together patients with similar requirements. It should be noted that therapeutic advances in neonatal medicine are advancing at such a rate that any set of criteria developed would be useful for only a limited time (Sauve,1979).

In an attempt to separate the population of newborn infants according to some index of care need, physicians generally classify babies into groups according to gestational age (Pierog,& Ferrara,1971) or into categories denoted by weight at birth (Harper,& Yoon,1974). More recently, neonates have been categorized using a scale which combines gestational age and birth weight (Sweet,1979). Based on this classification, it is claimed that the clinician can anticipate clinical problems peculiar to the category to which the patient belongs. The disadvantage inherent in these categorizations is that they do not give specific indications of the care requirements of these infants. There is little connection between these classifications and the three levels of care which have been identified by the American Academy of Pediatrics with regards to facility capability. The three levels of care which have been identified are minimal or convalescent, intermediate care, and intensive care. The services which should be provided at each of these levels are well defined (Committee on Perinatal Care,1977; NAACOG,1978).

2.5.1 Perinatal Care in Southern Alberta

Recognition of the need for increased collaboration among hospitals offering perinatal services in Southern

Alberta led concerned physicians and administrators to establish a committee to assess the situation and define levels of care for neonates (Haslam,1978). Intensive care has been defined as:

> ...the management of severely ill infants who require constant nursing and continuous cardiopulmonary and other forms of life support....Intermediate care refers to sick infants who do not require intensive care, but specialized medical-surgical nursing services including intravenous therapy, arterial blood gases, cardiopulmonary monitoring, exchange transfusions, oxygen administration and short-term ventilation (Haslam, 1978,p.2).

These definitions of intensive and intermediate care are general and subjective in nature. They are of limited usefulness in aiding the responsible physician to determine where his charge should be for treatment or in determining when the patient is ready to be moved elsewhere. As a result of this, a recommendation was made to the committee mentioned above.

> That a classification of patients in the Intensive Care Unit as to whether they need intensive care, intermediate care, or convalescent care be established so that the patients to be returned to the regional (or primary) hospitals can be properly identified (Deacon,1978,p.3).

It is the intent of the present study to develop and test for validity such a classification system.

2.6 Conclusions

Based on the literature reviewed relating to operations research and patient classification, the following are the major conclusions reached by this author.

(1) The assessment of patient need can be made on the basis

of the services required as a result of the patient health state.

(2) Operations research in the health field is not realizing its full potential, partly because of misunderstanding of each other's disciplines by the operations researchers and the health care practitioners and administrators.

(3) Based on the experience gained through the historical development of patient classification by levels of care, it may be concluded that some desireable characteristics of a patient classification system are; (1) simplicity, (2) objectivity, (3) comprehensiveness, (4) intervention-orientation, and (5) a patient-centered approach.

(4) The progressive patient care concept demonstrates that if the aim of the patient classification is not strictly to meet staffing purposes for nursing resources, the total care needs of the patient must be considered.

(5) Classification by types of care examines the total needs of the patient and therefore involves a greater degree of complexity of assessment. In order to make valid use of the many assessment variables and information, statistical techniques, such as discriminant analysis, should be used to correlate assessment variables with classification and to develop an objective classification procedure.

(6) The trend in classification seems to be toward the development of multi-dimensional, objective, and normative systems.

(7) Although relatively new to the field, three analytical techniques of great potential value to the future development of patient classification systems are decision analysis, discriminant analysis, and the Delphi technique.

(8) The recent trend in perinatal care to regionalization of services has led to the need for a neonate classification system enabling professionals to place these

patients in a hospital which can provide the most appropriate level of care.

2.7 Summary

In this chapter, an overview of the development of operations research and patient classification is presented. A model of patient need assessment is discussed on the basis of work by Donabedian. The application of this model to patient classification by levels of care is examined. Some trends are outlined and problems in the implementation of operations research are discussed. Patient classification, as part of operations research, reflects these trends and problems. Six important studies in patient classification by levels of care are reviewed and their contribution to the field is examined in evidence of the evolution of the classification methodology. The concept of progressive patient care is discussed because of its approach regarding total care needs, rather than nursing care needs alone. Although the methodology associated with progressive patient care is simplistic, it does provide an approach to classification based on total care. Four research studies are described in the field of patient classification by types of care which denote a trend to increased use of mathematical modelling and use of electronic computers to classify patients on a broad and complex range of assessment variables. The issues and limitations prevalent in patient classification are briefly discussed.

The relevance of patient classification to the field of neonatal intensive care is discussed with special emphasis on its role with regard to the regionalization of these units. The need for such an instrument to classify infants in Southern Alberta is expressed.

CHAPTER III

METHODOLOGY

3.1 Research Design

As outlined in Chapter I, the primary objective of this study was to develop and test for validity a classification instrument specific to the total care needs of intensive care nursery (ICN) patients. The study consisted of five major stages which were: (1) the development of criteria or definitions for each level of care; (2) the design of an instrument to be used in the assessment of service needs for ICN patients; (3) the collection of data using the assessment form; (4) the establishment of a criterion measure based on information collected; and (5) the establishment and validation of an objective classification procedure using the criterion measures established in stage 4. Each of these stages is presently discussed in greater detail.

3.2 Operational Definitions for Levels of Care Criteria

Levels of care criteria are not specific to particular diagnoses or medical problems. These criteria can be used to justify admission of continued stay in a particular setting on the basis of the type, number, and/or intensity of a combination of nursing, medical and ancillary services required by a patient in hospital.

The Southern Alberta Perinatal Advisory Committee, (hereafter referred to as SAPAC), has defined the three levels of care as Level I (continuing or convalescent), Level II (intermediate), and Level III (intensive). The criteria for these are given as:

> An intensive care area (tertiary or Level III) is designed for the management of severely ill infants who require constant nursing care and continuous cardiopulmonary and other forms of life support....
> Intermediate care refers to sick infants who do not require intensive care, but specialized medical-surgical nursing services including intravenous therapy, arterial blood gases, cardiopulmonary monitoring, exchange transfusions, oxygen administration and short-term ventilation....
> A convalescent care unit is designed for low birth weight infants who are not sick but require frequent feedings or for infants who no longer require intermediate care but who demand close observation for any reason (Haslam,1978,p.2-3).

These criteria, although providing a useful foundation, are deficient in several respects and should be refined further. First, the definitions are somewhat too vague with regard to the actual services provided at each level, leading to a largely subjective interpretation of terms such as 'severely ill' and 'sick'. In order to establish more operationally useful definitions, a more explicit description of services specific to each level of care was developed.

The second, and equally important, deficiency of the SAPAC levels of care criteria is that they are based largely on nursing services. No explicit allowance is made for the differences in type and number/complexity of physician services which may exist among the three levels of care in ICNs. Further, the services provided by support groups such as respiratory technology, social work, physiotherapy, and pharmacy may vary considerably among the levels and

should be considered when defining levels by intensity of total care required.

In order to overcome these major deficiencies in the existing criteria for ICN levels of care, a new set of criteria was developed using a modified version of the Delphi technique. A panel of professionals and practitioners in the field was established to define each of the three levels of neonatal care on a more explicit and multidisciplinary base. The criteria thus developed were outlined in terms of observable variables and it was assumed that they would therefore be acceptable to most ICN staff.

The panel of experts, (hereafter referred to as the Delphi panel), consisted of two neonatologists, two pediatricians, six ICN nurses and one respiratory technologist. This particular combination of experts resulted from a desire on the part of this author to have nursing representation from each of the six hospitals involved and medical representation from each of the cities involved. It was also thought that two neonatologists would be better than one in that the personal biases or opinions of each would be counter-balanced. Only one respiratory technologist was included as only the tertiary center offered this service specifically for the ICN. These individuals were selected for the Delphi panel on the basis of: (1) at least two years experience in the ICN setting; (2) sufficient interest in this study to volunteer their time and effort; and (3) their working membership in the intensive care nursery community of Southern Alberta. The Delphi panel used in this study was multidisciplinary in order to ensure that the total needs of the infant would be reflected in the resultant definitions.

The Delphi technique used in this study involved a 'round-robin' process. In the first round, a letter explain-

ing the process was mailed to each member of the group, and the question posed was, "What services could an infant be receiving that would justify his/her stay in the following levels on neonatal intensive care (intensive, intermediate, and continuing/convalescent)?" Participants were specifically asked to note that the levels-of-care criteria were based on services needed rather than symptoms or diagnoses.

The responses to this initial question were compiled into a master list. This list was then returned to the eleven members of the Delphi panel so that they could add to or delete from the list. In this manner, they had feedback on the criteria their working colleagues considered important, and they also had an opportunity to submit criteria they may have overlooked during the first round.

The responses to the second round resulted in a modified set of criteria for each level. This new set of criteria was constructed by incorporating the modifications made on the original list. The responses were remarkably similar. Resolution of cases presenting conflicting opinions on an item consisted of selecting the opinion for which a reasonable explanation was provided.

This second set of criteria was once more distributed to all Delphi panel members in a third round. A consensus of opinion among the members of the group on the acceptability of this last set of criteria resulted in it becoming the master list of levels-of-care criteria for ICNs.

The Delphi panel definitions for each level of care were developed after three 'rounds' of deliberation. A high degree of consensus was reached at this point with only three disagreements among the eleven members on the 33 items in the final list. The entire process took four months to complete. See Appendix A for results.

3.3 Design of the Assessment Form

In order to determine the resources required to meet the needs of the sick neonate, these needs must first be assessed. The assessment consists of the recording of patient health status and needs on a wide range of variables. This assessment then provides a basis for classification of patients such that they are grouped with others closely resembling them in health status and need for health services and resources.

3.3.1 The Assessment Variables

The assessment form which was used for data collection was composed of a collection of variables descriptive of selected characteristics of the patient. A review of the literature on patient classification by levels of care indicated that certain properties were desireable in the selection and orientation of these variables if the classification system developed was to be valid and useful. These properties were therefore incorporated in the construction of the Southern Alberta ICN assessment form and were: (1) intervention-orientation; (2) patient focus; (3) comprehensiveness; and (4) simplicity. The importance and relevance to neonatal intensive care of each of these characteristics of variables are discussed further.

Intervention-orientation is important in any classification by levels of care because it promotes the directness with which an indicator (variable) denotes the care required, avoids duplication of information, and lessens the subjectivity of classification. An example of this in the ICN would be in the assessment of a cyanotic infant. If the variable assessed is the illness state of the patient, this may give little or no information on actual care required,

whereas if the variable assessed is the need for respiratory assistance, then care required is directly implied. The assessor would necessarily be making a judgement of the patient's need on each variable. In order to ensure that reliability of the instrument would not be in jeopardy, the assessment instrument items were constructed so as to be readily understood and easily determined. The reliability of the assessment instrument was also empirically tested through an inter-rater agreement test on patients assessed simultaneously by two independent assessors. Content validity was considered to be adequate as the items constituting the assessment form were derived through close consultation with experts in the field.

The patient-centered approach is important in the selection and orientation of assessment variables. Since different institutions offering perinatal care have different capabilities in providing care, any assessment based on organizational functioning, such as respiratory technology or surgery, could not be used on a universal basis. Theoretically, one should be able to identify the need for such services regardless of the current location of the patient or the assessor. In practice however, the effect of having to assess a patient in terms of organizational services which a particular institution may or may not have, might colour the resulting assessment. A different approach could overcome this problem. The needs of the patient are universal, regardless of where the patient may be and as Donabedian denotes, the patient is the source of care requirements (1973). It is therefore more logical to base assessment variables in terms of patient needs rather than on organizational capabilities.

A patient-centered assessment could be used to derive an objective classification. At this point, it is important to separate classification, which should be patient-centered

from placement decisions, which are not necessarily patient-centered. The classification information should be used to make a placement decision, but placement is also affected by extraneous factors such as availability of beds and facilities, transportation requirements and staffing.

Comprehensiveness is seen as an essential requirement in the developmental stage of the assessment form mainly because of the weakness of human judgement in determining which variables are truly indicative of the level to which a patient belongs. An exhaustive list of all possible variables, potentially related to the levels-of-care definitions, reduces the subjectivity of personal bias and preference in the selection of indicators. In neonatal intensive care, one group of professionals may consider the need for respiratory assistance as the most crucial indicator of level-of-care, while another group may consider cardiopulmonary monitoring as the most crucial indicator. To overcome differences in subjective opinion, comprehensiveness is seen as a partial solution.

Since comprehensiveness would seem to be a contradictory property if one also needs a quick and simple tool, it was necessary to develop a final assessment tool in two separate steps. The first step included a comprehensive approach to the variables on which an infant could be evaluated. The second step involved a statistical analysis of this comprehensive list which delineated in an objective manner those variables which were most important in classification of the infant.

Simplicity of the final assessment/classification instrument is of crucial importance to its usefulness. One of the most common reasons for the failure of operations research in health care is that the researcher fails to understand the limitations of the health care system. If an

instrument is too long or complex, the users for whom it was intended will not employ it. In the intensive care nursery, the stochastic nature of patient health states and acuity of illness give the staff little time for additional administrative duties. The instrument they need must be short and simple, yet reasonably accurate. As outlined above, these objectives are not necessarily contradictory. In view of the fact that the quality of the information required on the assessment form is more important than the quantity, and that redundancy of information is inevitable in large sets of variables, statistical analysis can be applied in order to reduce a large number of assessment variables to a smaller number of truly meaningful variables, in terms of classification.

The selection of assessment variables to be included on the assessment form was established in several steps. The first was a review of medical charts on ICN patients and an overview of some of the literature on care in this setting. This enabled this investigator to become familiar with the 'language' of intensive care nurseries and to review the range of services offered in this area. Several areas of need for care for the individual baby were then identified and were seen as encompassing the total care needs of ICN patients. The areas of need were identified as: (1) nutrition; (2) respiration; (3) parent teaching and support; (4) medications; (5) supervision and monitoring; (6) diagnostic tests; and (7) treatments. The third step consisted of a review of activity in each area of need with members of several professional groups involved in ICN care; medical, nursing, social work and respiratory technology. Under each category of patient need for services, a comprehensive list of interventions was drawn up, reflecting multidisciplinary input. It should be kept in mind that the resulting list of interventions was intended to be compre-

hensive with regard to the special needs of ICN infants. Not included in this list were those 'interventions' which are common to all newborn infants, such as human touch/voice contact, diapering and bathing.

In summary, the assessment instrument was constructed to embody the four properties considered essential for a valid useful classification tool. These construction properties were intervention-orientation, patient focus, comprehensiveness and simplicity. See Appendix B for the final assessment form which was developed for the purpose of the present study.

3.3.2 Code Values for Variables in the Study Data

In order to provide the reader with a thorough description of the instrument, the system used for the procedure developed in this study is presented in Appendix C.

For the purpose of discriminant analysis and multiple regression, it was necessary to construct new 'umbrella' variables which were formed from the values of specified existing variables. Variables representing the criterion measure were constructed by obtaining the mean and the mode respectively of the classifications assigned to patients by each of the eleven members of the criterion panel. The mean of the eleven values was rounded to the nearest whole number resulting in a new variable called LEVEL with the three possible values; 1,2 or 3. This was used as the criterion measure for multiple regresssion. The mode of the eleven classifications was used to create a second variable called MODE, which was used as the criterion measure for discriminant analysis. MODE could also take on the possible values of 1,2 or 3. Agreement between MODE and LEVEL was perfect, with the exception of one patient out of a possible 138.

3.4 Collection of Data

The population from which the sample was drawn consisted of all neonates-at-risk in the service region covered by the following institutions: Calgary General Hospital, Foothills Provincial Hospital, Holy Cross Hospital, Lethbridge Municipal Hospital, Medicine Hat and District Hospital, and Salvation Army Grace Hospital (Calgary). Normal newborn infants who did not require special care were not included in the population under study. Also excluded from the study were all infants requiring special care or observation for less than 24 hours after birth.

3.4.1 Sampling

In order to keep the costs of the present study, in staff time and resources, within an acceptable level, the sample yielding the research data was limited to approximately 140 patients.

On any given day in 1979, there were approximately 55 patients in the Southern Alberta ICN units. The variation in length of stay for infants in the intensive care nursery is great, with extremes of less than 24 hours to more than six months. Exact length of stay statistics were not available. Estimates of average length of stay based on personal experience by professionals in this field varied from three to six weeks. This uncertainty necessitated an arbitrary decision on the length of time needed for collection of an adequate sample size. In order to include in the sample the greatest number of patients, without duplication, over the shortest period of time, cross-sectional and flow data were mixed. This 'accidental sampling' or 'chunk' data was a relatively weak form of sampling as it included in the

sample only those cases which were readily available (Kerlinger,1973). This was unfortunately difficult to control or improve, given some of the characteristics inherent in this study. One of these is that the largest sample which could be studied at any point in time was relatively small as stated earlier. This eliminated the possibility of using one 'snapshot' cross-sectional sample at a random point in time covering the entire ICN system. Further, given that the participation of the assessors in this study was completely voluntary and during working hours, it was impossible to set stringent rules on the timing of assessments. Assessors surveyed the infants in their care when time was available.

The volunteer assessor at each hospital was a nurse who had had at least two years experience in an ICN setting and who was not a part of the Delphi panel established earlier. This investigator instructed each assessor in person on the background and use of the instrument to be used in the assessment of each patient. Nurse-assessors were asked to survey each child admitted to the hospital ICN over a period of three weeks, as well as all the babies present at the time the survey started. Infants were assessed at least 24 hours after admission to the nursery. This step was instituted so that nurses could become familiar with the patient's needs, and to disqualify from the sample normal babies who were only admitted for short-term observation.

This sampling method resulted in a combination of cross-sectional data, from the assessment of neonates already in the ICN system at the start of the survey, and flow data, from the assessment fo those admitted to the ICN system during the three week duration of the survey. One major weakness of this approach is that the infants surveyed during the first day may not have been similar in

[illegible]

[illegible]

[illegible]

[illegible]

needs distribution to the new admissions assessed later in the survey.

Ideally, the sample of patients should have been chosen in a more random manner, prospectively over a longer period of time, based on a probability sampling method, resulting in a more representative sample. Alternatively, if enough sample size could be obtained, a future study in this area could carry out 'snap-shot' surveys of all patients in the Icn system on each of three or four days over a period of six months, at one and a half to two month intervals. The distribution of care requirements would probably be similar for each of these survey days and there would be little probability of duplication of cases in the resulting samples.

3.4.2 Assessment of Patients

Assessment of the patients in the sample was carried out by nurses who had at least two years experience with assessing the needs of patients in the ICN setting. Verbal presentations about the study had been made by this author to the ICN nursing staff in each of the six participating hospitals. At these presentations, the background and purpose of the classification project were explained as well as the need for volunteer assessors and their associated functions.

Each volunteer nurse-assessor was then given a one-to-one explanation of the assessment form and instruction in its use. The salient points stressed in these instructional sessions were normativeness of assessment, consultation with others involved in the care of each infant, and the requirement of determining immediate patient needs.

Assessors were asked to survey all patients in the ICN on the first day of the study. Any new patients being admitted after the first day were to be assessed at some point at least 24 hours after admission.

3.5 Establishment of a Criterion Measure

Each of the patients was assessed using the form developed in stage 2. This assessment form was completed by the nurse-assessor in close consultation with the responsible physician and other members of the ICN team. The assessment forms, which were randomly numbered, were then distributed to each member of the Delphi panel. The Delphi panel did not receive any information on the current location or identity of the cases which had been assessed. The random ordering of the assessment forms prevented the natural grouping of cases according to hospital or nursery type, so that the Delphi panel had to rely solely on the information on the assessment form itself.

Members of this panel, having developed a set of definitions for each level of care, had a common understanding of the criteria for membership to each level. This panel then independently assigned each patient to one of the three levels of care, convalescent, intermediate, or intensive, on the basis of the information on the assessment form. As was expected, unanimous assignment by the eleven members to one of the three levels occured for many cases in the sample (46 percent of all cases). In order to overcome the difficulty encountered when there was disagreement among the eleven panel members as to level membership of any particular case, the mean and the mode for this subjective classification were taken as the criterion measure for analysis of the data using multiple regression and discriminant analysis respectively. Each of these statistical techniques then yielded

the set of variables which were statistically the most crucial in predicting membership for the patients in the sample.

The intention of the instrument was to provide ICN staff in each hospital with a tool which they could use quickly and accurately to determine objectively where an infant belonged in terms of level of care. Since one of the problems associated with the origination of this research project was the overcrowding of tertiary (intensive) care nurseries by infants considered to be requiring less intensive care, there existed an historical basis for doubting the validity of subjective classification by the attending nurse or physician. It was therefore important that the criterion measure given by the Delphi panel be compared to the subjective opinion of the 'user,' in this case, the assessor.

In order to compare the two types of classification, assessors were asked to assign each case sampled to one of the three levels of care, according to their best judgement. This information was withheld from the Delphi panel as they had to base their decision on assessment variables only.

3.5.1 Limitations

Some of the limitations inherent in this stage of the development of the classification instrument should be pointed out. They are:

(1) the three classes indicating levels of care are assumed to be mutually exclusive, such that a patient must belong to one and only one of the three levels. Research evidence suggests that this may not be tenable for certain patients but discriminant analysis cannot be

applied without this assumption. Further,

(2) the classification assigned to each patient by the Delphi panel is assumed to be correct at the aggregate level; although there is in fact no error-free criterion measure, the subjective judgements of the experts must be accepted as valid. A final evaluation of this assumption can be made through the replication of similar studies.

3.6 Establishment of an Objective Classification

The assessment instrument was developed for the purpose of providing an information base with which to classify neonatal patients. Starting with a list of 43 variables indicating the need for services of each patient, in a number of areas, a reduction in the number of assessment variables to be included in the analysis was undertaken. All those variables which were difficult for assessors to determine, in particular those variables relating to parental needs for support and teaching, were eliminated. In many cases, the assessors had had no contact with the parents and were not in a position to assess the need for support or teaching. This exclusion of parent support and teaching stands as a serious limitation of this study, particularly in terms of comprehensiveness. Also excluded from further analysis were those variables which had inadequate variance within the sample, such as those in which only one case out of the total sample manifested a particular need.

This preliminary reduction resulted in a list of 30 variables which could be included in the analysis. Of these remaining variables, not all were of equal value in determining the level of care to which any given patient should be assigned. In order to determine which of these 30

variables were most meaningful in terms of predicting classification, two statistical techniques were applied to the data base and the subjective criterion measure. These techniques were multiple regression and discriminant analysis, both readily available on packaged computer programs, such as SPSS (Nie et al.,1975).

Multiple regression is a method of studying the effects and the magnitudes of the effects of more than one independent variable on one dependent variable using principles of correlation and regression (Kerlinger,1973). In this study, the 30 assessment variables were the independent variables as they were used as predictors, and the subjective criterion measure or classification was the dependent variable, as it was predicted. An interval scale for the dependent variable or criterion measure is assumed, as this is a requirement for multiple regression. Although some of the variables were of ordinal or nominal scale, the use of dummy variables enabled their use for multiple regression analysis. This analysis yielded an equation for predicting classification of infants consisting of a constant plus each of the 30 variables with its associated regression coefficient. Only the first seventeen variables entered in the stepwise multiple regression equation were chosen for the final analysis as all subsequent variables added to the regression equation after the seventeenth did not increase the coefficient of determination significantly.

Discriminant analysis addresses itself to the question of how individuals or cases in a sample can best be assigned to groups on the basis of several variables (Kerlinger,1973). When dealing with only two groups, discriminant analysis is little more than a multiple regression equation. In a study such as this one with more than two groups however, discriminant analysis goes beyond multiple regression methods. One important difference between the two statistical methods

is that discriminant analysis requires only a nominal scale for the criterion measure, whereas multiple regression needs at least an interval scale for this measurement.

The two resulting discriminant functions were constructed on the basis of only those variables which would maximally discriminate among the three groups. In this manner, using either multiple regression or discriminant analysis, the list of necessary variables on the assessment form was reduced and a compromise between comprehensiveness and simplicity was achieved without jeopardizing the objectivity of the instrument.

3.6.1 Validation

As noted above, an objective classification procedure depends on the existence of a criterion data base, and the validity of the criterion measure contained in the base. The criterion measure in this study was obtained by means of a multidisciplinary panel of eleven health professionals who had developed a common understanding of the criteria for membership to each level of care. The classification judgement made by this panel for each infant was subjective in nature, necessitating an examination of validity.

If we can assume that the criterion measure assigned by the panel of experts was error-free, then a measure of concurrent validity of the 'user' classification could be obtained by comparison of the assessors and the criterion panel. Since the criterion panel's classification was subjective and therefore open to error, this comparison could be viewed, at the very least, as a reliability check. Poor agreement between the two classification results would indicate:

(1) lack of concurrent validity for the 'user' classifica-

tion;

(2) low reliability of both measures; and/or

(3) lack of validity for the criterion panel classification (Bay et al.,1979).

The evaluation of the predictive validity of the criterion panel classification would then be based on comparison of objective classification results with the subjective criterion measure. Ordinarily, discriminant analysis is followed by the Bayesian classification (Nie et al.,1975). In this procedure, the cases in the study sample are used twice, once to derive discriminant functions, and a second time when the subjects are classified. Since the criterion measure is subject to error, and since the survey sample in this study is not large, the possibility exists that any one patient could distort the results. It has been found that, in general, the self-hit rates obtained using this approach are overly optimistic as estimates of validity (Bay et al.,1979). For the same reasons, a self-hit rate obtained from multiple regression analysis and application is also biased. As self-hit rates are relatively easily obtained and inexpensive (in terms of computer time), they do provide a useful estimate of the upper bounds of predictive validity.

In order to achieve an unbiased estimate of the predictive validity of a classification tool, ideally, the validation data must be independent of the criterion data from which the objective procedure is developed. This was achieved by classifying a few cases from the sample, using discriminant functions or multiple regression scores obtained from the sample with those few cases excluded. This had been done in previous research studies using discriminant analysis only, with some success and was known as the U-method or jackknife technique (Bay et al.,1979). The jackknife technique was particularly easy to apply using the

SPSS computer package for discriminant analysis by specifying those cases to be excluded from the construction of the discriminant functions, but including all cases in the Bayesian classification.

A considerably more tedious and time-consuming process was involved in applying jackknife technique to the multiple regression analysis. First, the selected cases had to be excluded from the analysis, then an equation had to be obtained for each set of excluded cases, and lastly, the regression equation had to be applied manually to each excluded set of cases. A score was thus obtained (indicating the predicted classification by level of care) which could be compared with the subjective classification assigned by the Delphi panel.

Due to the increased difficulty involved in applying jackknife technique to multiple regression analyses, cases were excluded in sets of 10 percent of the total sample. The total study sample was subdivided into sets of cases, such that each case was assigned randomly to one and only one set (subsample). In discriminant analysis, jackknife technique was applied to subsamples of 5 percent of the total study sample.

3.8 Methodological Limitations

The major methodological limitations encountered in this study revolve around three main areas which are sampling, assessment, and the criterion measure.

The sampling design of the study consists of a mixture of cross-sectional and flow data. The study was so designed in order to include in the sample the greatest possible number of cases. The sample, being made up of two sorts of

cases, is not necessarily representative of any specified population. Since the aim of the study was to determine which assessment factors were important in determining classification, rather than to describe the population, this 'weakness' is not as serious as it might be otherwise. One of the difficulties encountered with sampling was that the sample size of Level III (intensive) was considerably smaller than that for Levels I or II. This imbalance was not corrected for by weighting cases for discriminant analysis so that the size may have been inadequate on which to base an analysis, and subsequent generalizable statements.

The assessment of each case by a nurse-assessor was to be normative in nature, based on her knowledge of the patient and consultation with other members of the ICN team. The nurses in different institutions could not be expected to have had similar backgrounds or experience, and therefore their normative interpretations of needs could be expected to vary somewhat. An inter-hospital reliability test would have been desirable, but given the financial and temporal limitations of this research effort, was not possible. Furthermore, in the assessment of each infant, it was intended that the total care needs be examined. It was found that attending nurses and physicians were not always familiar with the psycho-social and teaching requirements of the parents, and therefore this area could not be included.

The criterion measure provided by the eleven member Delphi panel was assumed to be error-free. This group had developed together specific definitions for each level of ICN infant classification. Common agreement on the classification of each baby was not achieved for the entire sample. In most cases where there was some disagreement, the mean or the mode of the eleven decisions was taken as the criterion measure. This somewhat arbitrary solution to the difficulty probably incorporated some error in the final

criterion measure, as it was based on differences in human judgement. A measure of the error of the subjective criterion measure is available in validity testing of the objective classification procedure.

3.9 Summary

In summary, the investigator has described the several steps which were involved in the development of a classification instrument for neonatal patients. These were: (1) the development of definitions for each level of care; (2) the design of an assessment instrument; (3) a survey to collect information for a criterion data base; (4) the establishment of criterion measures; and (5) the reduction of the assessment variable list to develop an objective classification system. This last step also includes a description of the strategies used for validation of the classification system.

CHAPTER IV

DATA ANALYSIS AND RESULTS

For a three week period starting September 28,1979, infants in the intensive care nursery wards in six Southern Alberta hospitals were assessed as outlined in Chapter III. This assessment and classification took place simultaneously in all hospitals involved in the study.

This three week survey resulted in completed assessment /classification forms for a total of 154 patients. Of these, eleven were eliminated form further analysis as these were second assessments of the same children. During the survey period these babies had been assessed at one hospital, and had later been transferred to another hospital where they were assessed again. Although the need of these infants had often changed between the two assessments, only one of the two sets of data on each infant was selected (in a random manner) for inclusion in the sample. Another two assessed cases were eliminated, as they were not ICN patients. These were two infants who had left the hospital after birth and had returned during the survey period for cardiac care at one of the six hospitals, designated to provide this care. Of the remaining 141 cases, three more cases were eliminated from further analysis as the assessment forms on these infants were incomplete.

In the following analyses, data on assessment/classification forms from the remaining 138 cases were utilized.

4.1 Descriptive Analysis

As indicated earlier, patients were assessed at six hospitals in Southern Alberta over a three week period. Some of the major characteristics of the sample patients which were assessed and classified subjectively are outlined.

4.1.1 Demographic Characteristics

There were 22 cases (16 percent) of twin babies in the sample. This is of interest when compared to the incidence of twin births in the general population (1-2 percent). Because the patients in this study are newborn infants, age can be directly equated to length of stay. This measure provides some indication of the neonate's need for special care over time. The ages of the infants surveyed ranged from one to 120 days; 66.6 percent were one week of age or under; and 13.8 percent were over three weeks of age (Table 4.01). A large number of the patients were not over two days of age (44.4 percent). Males accounted for 52.0 percent of the sample.

The sample consisted of infants whose parents lived in the region of Southern Alberta and Southeastern British Columbia. Four of the survey hospitals were in a city of more than 500,000 people and each of the remaining two hospitals was in a city of approximately 50,000 people. The sample consisted of a majority of (76.1 percent) of infants whose parents resided in a city with a population greater than 100,000. Thirteen cases, or 9.4 percent, were infants whose parents lived in towns of less than 10,000 people.

A large majority (87.0 percent) of cases in the sample had a home address less than 50 kilometres away from the

Table 4.01

Age of Patients at Time of Assessment

Age Category (days)	No. of Patients	Percent
1 - 2	61	44.2
3 - 7	31	22.5
8 - 14	19	13.8
15 - 21	8	5.8
22 - 27	2	1.4
28 - 58	13	9.4
59 - 120	4	2.9
Total	138	100.0

hospital at which they were being treated. As such, most patients were within a reasonable travelling distance, and where patient transfers had occured, babies had generally been transported relatively short distances. Only 8.7 percent had a home address of more than 200 kilometres from the hospital (see Table 4.02). The greatest number of cases were assessed in the hospital offering tertiary care (Table 4.03).

Level of Care Classification

The distribution of cases in the sample among the six participating institutions can be seen in Table 4.03. At the time of assessment, the designated nurse-assessor in each institution was asked to classify each patient according to her best judgement of that individual's need for care. This was meant to provide a normative classification by levels of care for each child.

Each of the eleven transfers which took place during the survey period involved the tertiary centre, either as the receiving or originating institution. Five of these transfers were to more intense levels of care, three were to less intensive levels of care, and three were to equally intensive levels of care.

Patient Needs

Patient needs were assessed in seven general areas. These were: respiration; monitoring and supervision; medications; diagnostic tests; nutrition; treatments; and parental needs for support and teaching. An appreciation of the diversity of patient's needs in the sample can be gained by examining the distribution of needs for specific inter-

Table 4.02

Distance from Home of Patient at
Time of Assessment

Distance (km)	No. of Patients	Percent
0 - 50	120	87.0
51 - 200	6	4.3
greater than 200	12	8.7
Total	138	100.0

Table 4.03

Placement of Patients at Time of Assessment

Hospital	No. of Patients	Percent
Calgary General	16	11.6
Foothills	48	34.8
Salvation Army Grace	16	11.6
Holy Cross	42	30.4
Lethbridge Municipal	9	6.5
Medicine Hat & District	7	5.1
Total	138	100.0

ventions in each of the seven areas.

During the survey period, 41 (29.7 percent) cases were assessed to be in need of oxygen therapy. The majority of cases (60.2 percent) were assessed to need monitoring for vital signs every three to seven hours and 18.1 percent of all cases needed vital signs to be taken every one to two hours (Table 4.04). Although 61.7 percent of all cases in the sample did not require any antibiotic drugs, a considerable portion of the cases (27.5 percent) needed administration of antibiotics intravenously (Table 4.05).

The method of feeding required by the patients in the sample varied greatly, with 39.8 percent requiring breast or bottle feeding, 32.0 percent needing a combination of bottle and gavage feeding, and 23.9 percent requiring intravenous feeding. Table 4.06 delineates the different feeding requirements assessed within the sample.

The monitoring of blood gases is an important diagnotic aid in neonatal intensive care. The majority of cases did not require this, but of the 34.8 percent who did, most (26.8 percent) needed only capillary monitoring (Table 4.07).

One of the most distinquishing aspects of care for sick infants is the environment in which they are placed. Whereas all normal newborn infants are generally kept in cribs, the majority (68.2 percent) of neonatal patients in this sample were placed in isolettes and 10.1 percent were in radiant warmers (Table 4.08).

The prognosis was considered to be good for the largest portion of the infants in the sample, but for 16.0 percent of these babies, the prognosis was guarded or poor.

Table 4.04

Frequency of Vital Sign Monitoring

Frequency (hrs)	No. of Patients	Percent
every 1 - 2	25	18.1
every 3 - 7	83	60.2
every 8 or more	30	21.7
Total	138	100.0

Table 4.05

Method of Administration of
Antibiotics

Method	No. of Patients	Percent
None	85	61.7
Oral	1	0.7
Injection	14	10.1
Intravenous	38	27.5
Total	138	100.0

Table 4.06

Method of Feeding

Method	No. of Patients	Percent
Breast	15	10.9
Bottle-Q3 hours	22	15.9
Bottle-Q4 hours	18	13.0
Gavage	24	17.4
Bottle & Gavage	20	14.6
IV Therapy	33	23.9
Continuous Drip (I.V.)	2	1.4
Total Parenteral	4	2.9
Total	138	100.0

Table 4.07

Frequency and Type of Testing
Blood Gases

Type (per day)	No. of Patients	Percent
None	90	65.2
Capillary 4 or less	31	22.5
Capillary more than 4	6	4.3
Arterial 4 or less	3	2.2
Arterial more than 4	8	5.8
Total	138	100.0

Table 4.08

Patients' Environment at Time of Assessment

Environment	No. of Patients	Percent
Crib	30	21.7
Isolette	94	68.2
Radiant warmer	14	10.1
Total	138	100.0

Criterion Team Classification

As described in section 3.5 of the previous chapter, members of the Delphi panel were asked to classify each of the patients in the sample on the basis of information on the assessment forms. These subjective classifications were then processed, as outlined in section 3.3.2, to produce new variables. These were the criterion measures, LEVEL and MODE, used for multiple regression and discriminant analysis respectively.

LEVEL was derived by obtaining the mean of the eleven classifications for each patient and rounding to the nearest integer: 1,2 or 3. MODE was obtained by taking the mode of the eleven classification decisions for each patient in the sample. Because the number of classifications decisions was odd (eleven), there were no instances of a tie in the determination of the mode.

It can be seen in Table 4.09 that the numbers of cases assigned to each level varied somewhat among the eleven members of the criterion team. The range of cases assigned to Level I goes from a low of 55 to a high of 90. The numbers of cases assigned to Level II range from 36 to 68; and to Level III, from 8 to 20. The distribution of cases among the levels of care does not seem to be related to the professional discipline of the Delphi participant.

A breakdown of the agreement on classification for each patient in the sample is provided in Table 4.10. It can be seen that for 81.2 percent of the total sample, at least 72.7 percent of the criterion panel members were in agreement on the classification of that individual. Most of the strong disagreement evidenced arose over the classification of individuals as either Level I or Level II. It would seem that the difference between these two levels were not

Table 4.09

Classification of 138 Patients
by each Criterion Panel Member

Criterion Panel Member	Convalescent (I)	Intermediate (II)	Intensive (III)
Resp.tech.	90	36	12
Nurse - (1)	61	60	16
Nurse - (2)	84	38	16
Nurse - (3)	57	67	14
Nurse - (4)	66	52	20
Doctor - (1)	65	65	8
Doctor - (2)	56	65	17
Nurse - (5)	55	68	15
Doctor - (3)	80	40	18
Nurse - (6)	83	44	11
Doctor - (4)	61	59	18
LEVEL	64	58	16
MODE	64	57	17

Table 4.10

Breakdown of Agreement on Classification
among Criterion Panel

Percentage Agreement among 11 members	Number of Cases	Percent of Total Sample	Cumulative Percent
100	63	45.7	45.7
90.9	25	18.1	63.8
81.8	12	8.7	72.5
72.5	12	8.7	81.2
63.6	9	6.5	87.7
54.5	17*	12.3	100

TOTAL: 138

* 15 of these cases were classified either as Level I by 6 members of the criterion panel and as Level II by the remaining 5 members , or vice versa.

clearly enough differentiated.

4.1.2 Agreement on Subjective Classification

As outlined earlier, both the nurse-assessor and the members of the criterion panel were asked to subjectively classify each infant in the sample.

The nurse-assessors were in personal contact with each of the patients in the sample and were therefore expected to be more familiar with the 'real' needs of each individual than would be the criterion panel. The assessors had not participated in the formulation of operational definitions for each level of care. The criterion panel members, on the other hand, were not familiar with each baby and therefore based their judgements solely on the basis of assessment information provided them by the assessors. It was hoped that detachment form the individual patient would lead to a more objective classification. This panel did have a common understanding of the criteria for belonging to each level of care. As well, the members of the criterion panel all had considerable experience with ICN patients.

An analysis of the level of agreement between the nurse-assessors and the criterion panel was undertaken in order to determine the degree of subjective and concurrent validity. The overall agreement rate was 66.7 percent (Table 4.11). Although this is a slightly better rate than the rate of agreement obtained in a similar study by Bay et al. (1979), this could be due to the fact that the present study deals with only three levels, as opposed to five, thereby reducing the likelihood of error or deviance.

It is interesting to note that whereas nurse-assessors classified 37 cases in the sample as Level III, or tertiary,

Table 4.11

Comparison of Nurse-Assessor and
Criterion Panel Classification Results

Assessor \ Criterion Panel		LEVEL I	LEVEL II	LEVEL III	Total
LEVEL	I	46	10	0	56
LEVEL	II	16	29	0	45
LEVEL	III	2	18	17	37
Total		64	57	17	138

Overall agreement rate = 92/138 = 66.7%

the criterion panel classified only 17 cases at this level. This clearly indicates the strong impact on subjective classification of proximity to patients. Of the 46 cases on which the assessors and criterion team did not agree, a large portion (36 cases) indicated that the criterion panel judged the patient to belong to a level of less intensity than did the assessor. Only for 7.2 percent of the sample did the criterion panel assign a case to a level more intense than did the nurse-assessor.

4.2 Item Reliability

In order to determine the reliability of the assessment forms, a test of inter-rater reliability of each item in the form was carried out by comparing assessments made by two independent assessors on the same group of infants. Two nurses working in the tertiary care centre were asked to independently assess all infants in the ICN on the same day within a few hours of each other. A total of 24 infants were assessed for this purpose.

Most of the assessment variables had two alternatives which the assessors could choose, eight of the variables had three alternatives, one variable had four alternative answers, eight variables had five alternatives, and one variable had eight alternatives. The assessment form was constructed such that only one of the alternatives presented could be selected for each variable on the form. The measure indicating inter-rater reliability was the percentage agreement between the two assessors.

The variable list and the percentage agreement between assessors on each one is presented in Table 4.12. Perfect agreement was reached for 16 of the 43 variables. Agreements of 90 to 99 percent were obtained for a further 17

Table 4.12

Percentage Agreement between Reliability Assessors for all Assessment Variables

Var. No.	Description	Number of Alternatives	Percent Agree-ment
1.	Oxygen therapy	2	100
2.	Ventilator 1st 24hr	2	96.0
3.	Ventilator > 24hr	2	96.0
4.	Intubation	2	100
5.	Extubation	2	100
6.	Ventilated chest physiotherapy	2	100
7.	Non-ventilated chest physiotherapy	2	100
8.	Chest tube	2	100
9.	Method of nutrition	8	71.0
10.	Vital signs	3	67.0
11.	Blood pressure monitor	3	92.0
12.	Cardiac monitor	2	67.0
13.	Cardiac-respiratory monitor	2	71.0
14.	Apnea monitor	2	96.0
15.	Environment	3	100
16.	Blood Transfusion	4	100
17.	Emergency surgery	3	100
18.	Phototherapy	2	96.0
19.	NG/OG tube	2	100
20.	Vasoactive drugs	5	100
21.	Alkalai infusion	5	100
22.	Digitalization	5	88.0
23	Anticonvulsants	5	100
24.	Muscle relaxants	5	100
25.	Antibiotics	5	83.0

Table 4.12
(continued)

Var. No.	Description	No. of Alternatives	Percent Agree-ment
26.	Nutritional supplements	5	79.0
27.	Blood gases	5	79.0
28.	X-Rays	2	100
29.	Sepsis work-up	2	96.0
30.	Urine analysis	2	96.0
31.	C.B.C.	2	92.0
32.	Bilirubin	2	79.0
33.	Electrolytes	2	96.0
34.	EEG/EKG	2	100
35.	Other special tests	2	96.0
36.	Parent acceptance	3	92.0
37.	Parent relationship	3	92.0
38.	Emotional support	3	92.0
39.	Maternal experience	3	79.0
40.	Length of hospitalization	2	92.0
41.	Period of critical illness	2	92.0
42.	Number of set-backs	2	96.0
43.	Prognosis	2	96.0

Average percentage agreement for all assessment variables = 92.0 %

variables. In summary, agreement of 70 percent or better was achieved in 94 percent of all variables on the assessment form. It is interesting to note that for the classification portion of this form, there was perfect agreement between the two nurses.

These results indicate that the assessment/classification form was constructed in such a manner that an adequate degree of reliability was present.

4.3 Selection of Variables for Classification

The construction of the assessment form outlined in Chapter III resulted in a list of 43 assessment variables (each with two to eight alternatives), one classification variable, and six demographic variables. Survey data were collected using this form and a reduction in the number of variables to be included in further procedures was undertaken.

In the process of data collection it was revealed that the assessment variables relating to parental needs for support and teaching were difficult for assessors to complete. Often, the nurse-assessors had not been in contact with the parents sufficiently to determine these. This resulted in the elimination from further analysis of seven variables:

(1) parent acceptance;
(2) parental relationship;
(3) emotional support systems;
(4) maternal experience with sick infants;
(5) length of hospitalization;
(6) period of critical illness; and
(7) number of set-backs (refers to the number of times the infant's condition got worse- this was expected to put

quite a strain on the parents and therefore increase their need for support).

The first four variables listed above are fundamental to the concept of 'comprehensive' care, and their exclusion from further analysis presents a serious limitation to the completeness of the present study. This weakness was not picked up in the pre-test (item reliability) due to the fact that, in that test, these variables were known for 22 of the 24 patients assessed. It is not known why the larger sample should show such a difference in assessor familiarity with parental needs. Analysis of the results indicated that there was no significant difference in the assessment of the parental needs between the tertiary and other centers.

Of the 36 assessment variables remaining, some variables had to be excluded from further analysis, due to the fact that they did not apply to enough patients within the sample. It was thought that the inclusion of such 'rare' occurences would not be valid in terms of analysis. Those variables in which less than five of the 138 patients in the sample evidenced that particular need were therefore also eliminated from further analysis. These variables were:
(1) ventilator in first 24 hours;
(2) intubation;
(3) chest tube;
(4) alkalai infusion;
(5) anticonvulsants; and
(6) surgery.

The 30 assessment variables remaining were then selected to form the criterion data base for the development of an objective classification procedure. It should be kept in mind that the value of the information contained in the variables listed above (parental and other) need not be lost entirely. These can be presented as extraneous factors to be

considered as well as the 'objective' variables on the final assessment/classification instrument.

4.4 Multiple Regression

Assuming that the subjective criterion measure or classification of each individual by the criterion panel was of interval scale, multiple regression analysis was applied to the criterion data base. Only the 30 variables selected for further analysis were used in this step.

The SPSS computer program for multiple regression was used (Nie et al., 1975). On the basis of all cases in the sample, a prediction equation was obtained, through step-wise procedure. This equation, consisting of a constant plus a regression coefficient for each of the variables, is given in Table 4.13. It is interesting to note that, of the 30 variables, only one - ventilated chest physiotherapy - was excluded from the stepwise multiple regression as it did not meet the statistical criteria for inclusion. For this analysis, the default options for inclusion criteria of SPSS were used ($F = 0.01$, $T = 0.001$). These values place little restriction on the regression.

The overall accuracy of the prediction equation is reflected by R^2, the proportion of variation explained by the variables included in the regression equation. Table 4.13 shows that the final $R^2 = 0.918$, indicating that 92 percent of the variation in classification by levels of care is explained by the assessment variables used.

4.4.1 Predictive Validity : Self-Hit Rates

The next step was to classify each of the 138 babies

Table 4.13

Stepwise Multiple Regression Equation on
30 Selected Variables

Order of Entry	Variable	R Square	(B) Regression Coefficient
1	Blood gases	0.607	-0.032
2	Method of nutrition	0.723	-0.077
3	Apnea monitor	0.792	0.110
4	Urine analysis	0.825	0.082
5	Cardiac monitor	0.848	0.226
6	Oxygen therapy	0.873	0.235
7	Ventilator after 24 hours	0.883	0.282
8	Sepsis work-up	0.891	0.124
9	Environment	0.896	0.112
10	Nutritional supplements	0.899	-0.096
11	Vital signs	0.903	0.084
12	Cardiac-respiratory monitor	0.906	0.163
13	Blood or other transfusion	0.908	0.079
14	Antibiotics	0.909	-0.035
15	Nonventilated chest physio.	0.911	-0.112
16	Prognosis	0.913	-0.054
17	Muscle relaxant	0.914	0.099
18	Vasoactive	0.915	-0.076
19	Non-routine biochem.	0.916	0.088
20	Extubation	0.917	0.111
21	Bilirubin	0.917	-0.024
22	Electrolytes	0.918	0.047
23	EEG/EKG	0.918	0.084
24	Blood pressure monitor	0.918	0.042
25	CBC	0.918	-0.023

Table 4.13
(continued)

Order of Entry	Variable	R Square	(B) Regression Coefficient
26	X-Rays	0.918	0.027
27	NG or OG tube	0.918	-0.027
28	Phototherapy	0.918	-0.009
29	Digitalization	0.918	0.009
	CONSTANT		-0.263

in the sample using the regression equation produced above. The objective classification thus obtained was then compared to the subjective classification obtained from the criterion panel, that is the mean of these classifications for each patient, rounded to the nearest integer: 1,2 or 3. An examination of the agreements between these two classifications of the same subjects (Table 4.14) indicates that a hit rate of 88.4 percent was obtained. This hit rate is a self-hit rate in that the same cases are used in the development of the prediction equation and in the objective classification procedure. The 88.4 percent 'accuracy' indicates the highest possible value for predictive validity which the regression equation could have.

A comparison of the objective classification obtained through multiple regression and the subjective classification obtained from the nurse-assessors was also carried out. Table 4.15 shows that this comparison resulted in a hit rate of 64.5 percent.

4.4.2 Reduction of Variables in Regression Equation

The aim of this project being to develop and test for validity a useful classification procedure in the ICN setting, an attempt was made to further simplify the assessment procedure. Stepwise multiple regression yielded a list of the variables in the regression equation in their order of entry. This procedure was used in order that a subset of predictor variables could be identified which would yield an optimal prediction equation with as few predictor variables as possible. The increase in value of the coefficient of determination (R^2) afforded by each new variable added to the stepwise procedure is given in Table 4.13.

Table 4.14

Results of Multiple Regression and Objective Classification* Versus Criterion Panel Classification

M.R. Classification \ Criterion Panel		LEVEL I	LEVEL II	LEVEL III	Total
LEVEL	I	61	11	0	72
	II	3	46	1	50
	III	0	1	15	16
Total		64	58	16	138

Self-hit rate = 122/138 = 88.4%

* Multiple regression based on criterion panel measures and selected set of 30 variables

Table 4.15

Results of Multiple Regression and Objective Classification* Versus Classification by Nurse-Assessors

M.R. Classification \ Nurse-Assessors	LEVEL I	II	III	Total
LEVEL I	49	21	2	72
II	7	24	19	50
III	0	0	16	16
Total	56	45	37	138

Agreement rate = 89/138 = 64.5%

* Multiple regression based on criterion panel measures and selected set of 30 variables.

The first seventeen variables were selected as the most important predictors using multiple regression in the final development of a classification procedure. It can be seen that variables entered in the stepwise equation after the seventeenth step increase the value of R^2 by less than 0.001 (before rounding off).

Using only the first seventeen variables selected above, a second prediction equation was obtained through multiple regression. This is the equation (Table 4.16) which was used in the analyses to follow.

4.4.3 Predictive Validity : Cross-Validation

In order to determine the predictive validity of a classification procedure using only the selected 17 variables, a revised version of the jackknife technique was employed.

The total sample of 138 patients was randomly sub-divided into 10 subsets, with an average of 14 patients in each subset. This modified version was adopted because the costs of running a 'pure' jackknife technique on the computer would have been prohibitive. Regression equations were thus obtained for the 10 sets of sample cases in which all but one of the 10 subsets were included in the criterion data base. Each of these regression equations was then applied to the excluded subset of cases and a measure of cross-validity was thus obtained.

It can be seen in Table 4.17 that this classification procedure yielded a cross-hit rate of 82.6 percent. It is interesting to note that the largest source of error (16 cases or 11.6 percent) came from cases which were subject-ively classified as Level II, but were objectively classi-

Table 4.16

Stepwise Multiple Regression Equation
on 17 Top Variables

Order of Entry	Variable	Regression Coefficient (B)
1	Blood gases	-0.032
2	Method of nutrition	-0.077
3	Apnea monitor	0.110
4	Urine analysis	0.082
5	Cardiac monitor	0.226
6	Oxygen therapy	0.235
7	Environment	0.282
8	Nutritional supplements	-0.096
9	Vital signs	0.084
10	Antibiotics	-0.035
11	Nonventilated chest physio.	-0.112
12	Ventilator after 24 hours	0.282
13	Sepsis work-up	0.124
14	Cardiac-respiratory monitor	0.163
15	Blood or other transfusions	0.079
16	Prognosis	-0.054
17	Muscle relaxant	0.099
	CONSTANT	-0.263

Table 4.17

Results of 10% Jackknife Classification
Criterion Panel Assessment, 17 Variables

M.R. Classification \ Criterion Panel		LEVEL I	II	III	Total
LEVEL	I	59	16	0	75
	II	5	41	2	48
	III	0	1	14	15
Total		64	58	16	138

Cross-hit rate = 114/138 =82.6%

fied Level I, the lowest level.

4.5 Discriminant Analysis

In a manner similar to that used for multiple regression, analysis of the data was carried out using discriminant analysis. The 30 variables selected for further analysis were utilized, as were all cases in the sample. Discriminant analysis was carried out using the appropriate sub-program in the SPSS computer package (Nie et al., 1975).

On the basis of all cases in the sample, two functions were obtained through stepwise discriminant analysis. The selection criteria used (MAHAL) sought to maximize the Mahalonobis distance between the two closest groups. Cases were not weighted so that the contribution (i.e. number of cases) of each level to the discriminant function was not necessarily equal. This was particularly true for Level III. The maximum number of steps was set at 20 and the minimum F value for entry into the linear model equation was set at 1.0, as was the F value for removal. A minimum tolerance (T) level of 0.001 was used. For this analysis, prior probabilities for Bayesian classification were taken to be proportional to the number of patients in each level, according to subjective, criterion panel classification.

The discriminant analysis of the sample data using the 30 selected variables resulted in two discriminant functions as the data had been presented in terms of three groups. Only 14 of the original 30 variables had met the criteria for inclusion in these functions, which are presented in Table 4.18. The order of entry of the 14 variables is shown in Table 4.19, as well as the Wilks lambda associated with each. The small Wilks lambda (0.088)

Table 4.18

Standardized Canonical Discriminant
Function Coefficients

Variable	Function 1	Function 2
Oxygen therapy	0.287	-0.497
Extubation	0.039	0.313
Nonventilated chest physio	-0.275	-0.532
Vital signs	0.043	-0.221
Cardiac monitor	0.394	-0.251
Apnea monitor	0.459	0.235
Digitalization	0.276	0.139
Antibiotics	-0.164	0.315
Nutritional supplements	-0.505	-0.419
Blood gases	-0.319	-0.835
Urine analysis	0.298	0.371
Non-routine biochemistry	0.087	-0.425
Method of nutrition	-0.395	0.568
Environment	0.188	-0.066

Table 4.19

Results of Stepwise Discriminant Analysis
Using Criterion Panel Assessment, 30 Variables

Order of Entry	Variable	Wilks Lambda
1	Oxygen therapy	0.552
2	Cardiac monitor	0.390
3	Method of nutrition	0.268
4	Urine analysis	0.236
5	Non-routine biochemistry	0.214
6	Environment	0.202
7	Antibiotics	0.191
8	Vital signs	0.149
9	Nutritional supplements	0.143
10	Extubation	0.138
11	Apnea monitor	0.131
12	Blood gases	0.109
13	Digitalization	0.104
14	Non-ventilated chest physio.	0.088

obtained for the last variable entered in the analysis means that considerable discriminant power exists in the variables being used (Nie et al.,1975).

4.5.1 Predictive Validity : Self-Hit Rates

As was done using multiple regression, the next step in the use of discriminant analysis was to classify each of the 138 patients using the derived functions. The self-hit rate obtained for Bayesian classification versus the subjective classification provided by the criterion panel was 89.1 percent (Table 4.20).

The comparison of Bayesian classification to classification by assessors (Table 4.21) shows a considerable drop in the agreement rate.

4.5.2 Predictive Validity : Cross-Validation

Since the predictive validity indicated by the self-hit rates tend to be somewhat optimistic, the jackknife technique was used to determine the cross-validity of Bayesian classification. The total sample of 138 cases was randomly subdivided into 20 subsets. Twenty discriminant analyses were carried out, with each of the subsets excluded at a time. This resulted in the development of discriminant functions independent of the information contained in the subset being excluded. The Bayesian classification procedure was then applied to all cases, including those in the excluded subset. Table 4.22 demonstrates the cross-hit rate of 83.3 percent which was obtained.

Table 4.20

Results of Discriminant Analysis
and Bayesian Classification
Versus Criterion Panel Classification

	Bayesian \ Criterion Panel	LEVEL I	LEVEL II	LEVEL III	Total
LEVEL	I	61	9	0	70
	II	3	46	1	50
	III	0	2	16	18
	Total	64	57	17	138

Self-hit rate = 123/138 = 89.1%

Table 4.21

Results of Discriminant Analysis
and Bayesian Classification*
Versus Nurse-Assessor Classification

Bayesian / Nurse-Assessor	I	II (LEVEL)	III	Total
LEVEL I	50	18	2	70
II	6	27	17	50
III	0	0	18	18
Total	56	45	37	138

Agreement rate = 95/138 = 68.8%

* on basis of criterion panel assessment on 14 variables.

Table 4.22

Results of 5% Jackknife Classification
Criterion Panel Assessment, 14 Variables

Bayesian \ Criterion Panel	LEVEL I	LEVEL II	LEVEL III	Total
LEVEL I	59	11	0	70
LEVEL II	5	43	4	52
LEVEL III	0	3	13	16
Total	64	57	17	138

Cross-hit rate = 115/138 = 83.3%

4.6 Step-Wise Discrimination among Variables

Application of the stepwise procedures to the 30 variables selected for further analysis resulted in two different shortened lists of assessment variables. Tables 4.16 and 4.19 show the results of multiple regression and discriminant analysis respectively, with the selected variables in their order of entry.

Of the variables selected for their predictive power by each stepwise procedure, eleven were common to both multiple regression and discriminant analysis. These are presented in Table 4.23, as well as six additional variables included through multiple regression only, and three more variables included through discriminant analysis only. The value for Spearman's rank correlation (r_s) obtained for the set of variables shared by the two stepwise procedures was $r_s = -0.41$ (not significant at the 0.05 level). This indicates that there is no correspondence between the order of entry of variables in multiple regression and that in discriminant analysis.

Of the 30 variables selected for use in the stepwise procedures, 11 were selected by both procedures as important predictors of classification. A further 6 were indicated by multiple regression to be important and a further three by discriminant analysis. This meant that, of the original 30 variables, 20 had been included in the multiple regression and/or the discriminant analysis equations. A total of 10 variables were excluded by both procedures. These were:

(1) vasoactive drugs;
(2) bilirubin;
(3) electrolytes;
(4) EEG/EKG;

Table 4.23

Predictive Variables
(as selected by step-wise procedures)

Variable	Order of Entry: Multiple Regression	Order of Entry: Discriminant Analysis
Blood gases	1	12
Method of nutrition	2	3
Apnea monitor	3	11
Urine analysis	4	4
Cardiac monitor	5	2
Oxygen therapy	6	1
Environment	9	6
Nutritional supplements	10	9
Vital signs	11	8
Antibiotics	14	7
Nonventilated chest physio.	15	14
Ventilation after 24 hours	7	-
Sepsis work-up	8	-
Cardiac-respiratory monitor	12	-
Blood or other transfusions	13	-
Prognosis	16	-
Muscle relaxant	17	-
Non-routine biochemistry	-	5
Extubation	-	10
Digitalization	-	13

(5) blood pressure monitor;
(6) CBC;
(7) X-rays;
(8) NG or OG tube;
(9) phototherapy; and
(10) ventilated chest physiotherapy.

The exclusion of these assessment variables from both prediction equations for classification indicates that these variables: (a) are redundant, in that the information they provide is already in the equation; or/and (b) are immaterial, in that the information they provide is of no consequence to classification by levels of care.

4.7 Conclusions

A comparison of the classification of each patient by nurse-assessors with that by the criterion panel indicated an agreement rate of 66.7 percent. Since the criterion panel based their classification solely on information provided by the assessors, this low agreement rate must have resulted from differences in opinion between the two groups on criteria for belonging to a given level. As well, the fact that many different assessors were involved may bave added to the inconsistency of classification within this group. The fact that, of the 46 disagreements, 36 cases (78.3 percent) were classified as less intensive by the criterion panel than by the assessors, indicated that nurse-assessors tended to have lower criteria for admitting infants to the more intensive levels.

The results obtained for self-hit rates derived using multiple regression and discriminant analysis were 88.4 and 89.1 percent respectively. This led to the conclusion that there was no significant difference in the optimum

level of predictive validity between the two analyses. This conclusion was further supported by the results obtained for self-hit rates for nurse-assessor classification with the objective classifications.

Application of the jackknife technique for further testing the predictive validity of the instrument resulted in cross-hit rates of 82.6 and 83.3 percent for the mutilple regression and discriminant analysis respectively. The difference between self-hit rates and cross-hit rates for both analytical techniques was similar (5.8 percent). This was much less than the difference reported in a similar study by Bay et al. (979), where a difference of 20 percent was noted between self-hit rates and the cross-hit rates. The reasons for this are probably related to the fact that the study by Bay et al. involved 5 classess rather than 3, and the number of assessment variables used was also much higher. The lower cross-hit rate found in the present study indicated that there may have been some inconsistency in the subjective classification by the criterion panel. The results showing the breakdown of the mean and the mode of the panel classifications would tend to support this.

The prediction equations provided by both multiple regression and discriminant analysis were very similar in predictive validity. Because multiple regression is a less complex procedure in deriving a classification level than is discriminant analysis, the prediction equation resulting from stepwise multiple regression was chosen to form the base for the final, modified assessment instrument. This instrument is presented in Appendix D, and its use is demonstrated and explained.

4.8 Summary

In this chapter, the results of data analysis were presented. A descriptive analysis of data on the sample patients yielded an overview of demographic characteristics. An assessment variable from each general area of care (e.g., diagnostic tests) was reviewed in order to give the reader some idea of the diversity of needs for care within the sample.

A comparison of the subjective classification made by nurse-assessors and by the criterion panel showed that the latter tended to assign patients to less intensive levels of care. This may reflect that proximity to patients (and the familiarity developed) makes nurses over-estimate the degree of intensity of care required. On the other hand, it may also be possible that those nearest the neonate (in this case, the nurse-assessors) have a better understanding of the needs of the patient, and that these needs are not being identified in the assessment information.

Results of inter-judge reliability testing indicated that the assessment form had an adequate degree of reliability. The predictive validity of the shortened lists of assessment variables was determined through multiple regression and discriminant analysis, to be satisfactory, although the problem of consistency in judgement (for subjective classification) does remain.

CHAPTER V

CONCLUSION

The purpose of this chapter is to briefly summarize the study undertaken on patient classification by levels of care for intensive care nurseries. An overview is provided of the rationale and methodology involved in the development and validation of an ICN classification procedure. An outline is presented of the major conclusions drawn from this research and the major limitations inherent in the study are discussed. In closing, further research on this topic is recommended.

5.1 Summary

The objective of this study was to develop and test for validity a classification instrument designed to meet the needs of patients in intensive care nurseries. It was hoped that such an instrument would ultimately improve care by facilitating communication between institutions and between health professionals, and by improving placement decisions.

A review of the literature was undertaken in order to determine how best to fulfill the stated objectives, given the limited resources available. An overview of developments in the process and implementation of operations research outlined some of the techniques for, uses of and problems with the classification systems, as developed

through operations research, were examined in order to determine which approaches and methodologies had been utilized in the past. Some of the difficulties encountered in assuring validity of these various classification schemes were recognized and, based on this information, and on a review of the analytic techniques available, a methodology for the present study was developed.

The first major step in the methodology was the development of criteria or definitions for each level of care. This was done through the use of the Delphi technique with a multidisciplinary group of health professionals. This approach was selected as the optimum one for efficiency in the use of resources and comprehensiveness (several panel members from different disciplines) in terms of breadth of knowledge and expertise.

An instrument for assessment was constructed in consultation with nursing, medical, and ancillary ICN staff. The four major characteristics incorporated in the assessment form were patient focus, intervention-orientation, comprehensiveness, and simplicity. Several areas of need for care were identified for ICN infants and a thorough list of assessment variables was drawn up for each area. These were: nutrition; respiration; parent teaching and support; medications; supervision and monitoring; diagnostic tests; and treatments.

The third step consisted of data collection in a survey carried out over a period of three weeks duration in six different institutions. A total of 138 patients, in six hospitals, was assessed and subjectively classified by the assessor. An evaluation of the item reliability was also undertaken through calculation of inter-judge agreement on assessment of a separate, smaller group of patients by two independent assessors.

The fourth major step was the establishment of a subjectively based criterion measure. Members of the group who had, through the Delphi technique, developed definitions for each level classified each patient in the total sample on the basis of the information on the assessment form. This subjective classification was then used as a criterion measure to develop an objective classification model by applying discriminant analysis and multiple regression techniques. The predictive validity of both techniques was calculated to be at an acceptable level (83.3 percent) using the jackknife technique.

These data analyses provided the basis for a classification procedure for ICN patients.

5.2 Conclusions

The major conclusions reached by this author as a result of this research effort are outlined below. These are presented under two headings, according to the aspect of the project under which the conclusions were drawn; literature review and data analysis.

5.2.1 Literature Review

A review of the literature on operations research in health care indicated that:

(1) Operations research in the health field is not realizing its full potential. This is partly due to limited understanding of the health care system, on the part of the researcher, but the responsibility also lies with the health care administrators and practitioners.

(2) Three analytical techniques of great potential value to the future of patient classification systems are decision analysis, discriminant analysis, and the Delphi technique.

In the area of patient classification, a selected review of the literature led to the following observations.

(3) The assessment of patient needs can be made on the basis of services required as a result of the patient's health state.

(4) Some desireable characteristics of patient classification systems are intervention-orientation, patient focus, simplicity (of use), and comprehensiveness (in development).

(5) Patient classification systems should be developed on the basis of the total care needs of the patient for services.

(6) In order to make full and valid use of the large amount and complexity of information necessary in the assessment of total care needs, statistical techniques should be used to develop objective classification procedures.

(7) The trend in the development of classification systems seems to be toward the development of multidisciplinary, multidimensional, objective and normative systems.

5.2.2 Data Analysis

The information collected using the methodology outlined in Chapter III and the subsequent analysis of this data revealed the following.

(1) Levels of care criteria can be developed on a multidisciplinary basis, providing a thorough definition for each level.

(2) The Delphi technique provides an efficient method for developing levels of care criteria, particularly when the Delphi participants belong to different disciplines.

(3) Results indicate that nurse-assessors, who are in close contact with the patients, tend to assign infants to more intensive levels of care than do the more detached (impersonal) members of the criterion panel.

(4) An objective classification procedure can be developed on the basis of a subjective criterion measure, resulting in an adequate degree of predictive validity.

(5) The use of a large number of assessment variables tends to incorporate a degree of redundancy in the assessment process. A selective reduction in the number of variables can be achieved with little loss of predictive validity.

(6) The 11 assessment variables which were objectively selected (through both discriminant analysis and multiple regression) as the best indicators for classification of ICN patients were:

1. Blood gases	7. Environment
2. Method of nutrition	8. Nutritional supplements
3. Apnea monitor	9. Vital signs
4. Urine analysis	10. Antibiotics
5. Cardiac monitor	11. Non-ventilated chest physio.
6. Oxygen therapy	

(7) The jackknife technique provides a useful indicator of predictive validity in an objective classification tool.

5.3 Limitations

Any interpretation of the results and conclusions presented here must be tempered with an appreciation of the methodological limitations inherent in this study.

(1) Resource constraints forced the study to be limited in scope and time involved. Since the assessment of the patients was done on a voluntary basis during working hours, the depth of assessment could not be extensive and the time period of the survey could not be longer. Because of these limitations, factors such as the teaching and support needs of parents could not be determined for all infants, thereby constituting a major limitation in the attempt to develop a comprehensive classification instrument.

(2) Sampling consisted of two types of data collection (cross-sectional and flow) resulting in generalizability difficulties with regard to the population being described.

(3) Total sample size of 138 patients was adequate, but the levels of care subsamples showed considerable variation, particularly for Level III (tertiary) patients. The small sample size for this group may have been inadequate for analytical purposes.

(4) The validity of the assumptions made in establishing the criterion measure could be questioned. Human judgement (not necessarily error-free or consistent) was used to construct the criterion measure, therefore incorporating these weaknesses in the construction process.

(5) The assessment of patients was normative in nature and was carried out by six independent assessors. The subjectivity was therefore increased by this approach since no two assessors could be expected to bring the same background or experience to bear on their judgements.

(6) In theory, the jackknife technique was to exclude one case at a time, develop discriminant functions, and then use these to classify that case. The costs of using a pure jackknife technique would have been very high, therefore a modified jackknife technique was used to determine predictive validity. Samples of 10 percent and 5 percent of the total sample were excluded for multiple regression and discriminant analysis respectively.

(7) The results of this study apply only to one geographical area with its patterns of medical and nursing care at a given point in time. The generalizability of the results to other geographical populations, or to the same population over a longer time period is unknown.

(8) No attempt was made to establish the relationship between the classification system developed here and the patterns of professional communications or quality of placement decisions.

5.4 Recommendations

(1) The instrument developed in this project did not, as originally intended, include consideration of parental needs for support and teaching. It is strongly recommended that further work be carried out with this instrument in order to assess and incorporate parental needs.

(2) The instrument developed in this project is described in Appendix D. Further work should be carried out on the existing data to render the final assessment instrument more practical for users.

(3) An inter-hospital reliability test ought to be performed to determine the degree of mutual understanding on assessment variables and criteria among the hospitals. This could be carried out by having independent nurses and physicians, familiar with ICN care, assess infants in all the regional institutions, simultaneously with an assessor from the hospital.

(4) The generalizability of this instrument to populations in other regions should be tested. As well, the adequacy of the small sample size for Level III (intensive) used in the present study should be determined. This could be done by repeating the survey while controlling for this.

Pending the improvements and further testing of the instrument, as suggested above, the following stages are recommended:

(5) Further research and demonstration projects are recommended in order to increase the data base, to define new or additional variables, and to study the adequacy of the criterion measure developed in this research effort.

(6) Health care agencies throughout Alberta and other regions should assess the utility of the instrument developed in this study, and experiment further to determine its validity for their region.

(7) Health care planners should assess the utility of tools such as the one developed here in terms of predicting regional health care needs for resources over time.

(8) Professional groups within the institutions (particularly nursing and respiratory technology) should assess the utility of the instrument in predicting staffing needs.

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Appendix A

Delphi Process in Development of Levels of Care Criteria

A.1 Introductory Letter to Participants

A.2 Beginning Questionnaire

A.3 Round Two Letter and Questionnaire

A.4 Round Three Letter and Questionnaire

A.5 Consensus

56 Silverstone PL.N.W.,
Calgary, Alta.,
T3B 4Y9
June 15,1979

A.1 Introductory Letter

Thank you for your interest in and committtment to participation in the Southern Alberta neonatal classification project which I am undertaking. It is my understanding that you have read and accepted the research proposal for this project and are willing to participate in the 'Delphi' group.

The Delphi group consists of twelve individuals, each of which are professionally involved with neonatal intensive care in a medical, nursing, or para-medical capacity. The purpose of this group is two-fold. The first aim is to develop working definitions for the three levels of neonatal intensive care, and the second is to categorize a sample of patients according to these definitions.

The Delphi Technique was developed several years ago as a method for obtaining the opinion of a group of experts on a particular matter without requiring time consuming meetings. Additionally, it has been empirically demonstrated to produce more comprehensive criteria or standards than unstructured face-to-face meetings.

The first step of the Delphi Technique is this letter and the attached questionnaire. It has as its purpose obtaining criteria from you that you feel are important in deciding to which level of care an infant should be assigned, on the basis of his needs for services. Please note that these criteria are based on services needed rather than on diagnosis or symptoms. You should assume that regardless of location or patient condition,

...2

the services needed by an individual patient will be assessed appropriately, and should concentrate on those services which are indicative of each level of care.

The second step of the Delphi will take place after I receive your responses to this first round. Your individual lists of criteria will be combined into a single master list and resubmitted to you for your consideration and the opportunity to add or delete items that in your judgement should or should not be included. This will provide you with feedback on the first round and allow you to submit criteria which you may have initially overlooked. The amemded definitions will be returned to me and I will again combine individual responses and return a master set of definitions to you. The third, and probably final step of the first phase in the Delphi Technique will be to reconsider this list of criteria.

This round-robin process generates criteria that are an aggregate of committee members' best judgement. However, it requires your best effort and prompt response. For this reason, please complete the attached questionnaire and return it within one week. If you should have any questions regarding the questionnaire or the technique, I can be reached at 288-0266 in Calgary, and will be pleased to assist you in any way.

I hope that this procedure meets with your approval. Thank you for your participation.

Sincerely,

Nicole Bertinshaw

A.2 Beginning Questionnaire

DELPHI GROUP: Phase 1 - Definitions of Levels of Care

Responses to this questionnaire should be as individualistic and as free of external influences as possible. Your participation will be most valuable if the opinions expressed are your own and not made in consultation with other members of the group.

The Delphi group is made up of physicians, nurses, and paramedicals. As a member of one of these professions, your depth of understanding of the services rendered by the others will be determined largely by your experience. Your responses are not required to be comprehensive individually, as you are part of a multidisciplinary group. It is the purpose of the questionnaire to bring out the criteria you think most important in determining level of care without needing to be lengthy and detailed in your answers.

The definitions for the three levels of care in neonatal intensive care given by the Southern Alberta Perinatal Advisory Committee are as follows:

> An intensive care area (tertiary or level 3 unit) is designed for the management of severely ill infants who require constant nursing and continuous cardiopulmonary and other forms of life support.
>
> Intermediate care refers to sick infants who do not require intensive care, but specialized medical-surgical nursing services, including intravenous therapy, arterial blood gases, cardiopulmonary monitoring, exchange transfusions, oxygen administration, and short-term mechanical ventilation.
>
> A convalescent care unit is designed for low birth weight infants who are not sick but require frequent feedings or for infants who no longer require intermediate care but who demand close observation for any reason.
>
> (Southern Alberta Perinatal Advisory Committee, 1978, p.2-3)

These definitions are useful as a basis for further development in order to reach an operational, multidisciplinary understanding of what each level entails with regards to services.

Delphi Group Questionnaire

First Round

What services could an infant be receiving that would justify his / her stay in the following levels of neonatal intensive care?

Intensive (tertiary) :

Intermediate (secondary) :

Continuing or Convalescent (secondary) :

****

Please detach this sheet when completed and return to me by mail at 56 Silverstone Pl.N.W.
Calgary, Alberta
Telephone 288-0266

Thank you.

Nicole Bertinshaw

A.3 Round Two Letter and Questionnaire

August 13, 1979

Dear Delphi Participant,

The attached sheets comprise the second round of the delphi process to generate " Definitions of Levels of Care for Southern Alberta Neonatal Intensive Care". On the first round you were asked to list criteria that you considered most important in determining levels of care. The response rate to the first round was slightly over 80% and after duplicate or similar responses were eliminated, the yield was approximately 15 criteria for each level.

In preparing Round Two, it was decided that criteria which were listed in your total responses in more than one level would only appear in the less intensive one. For example, exchange transfusions were listed as a criteria justifying both intermediate and intensive care levels, therefore it appears as a criteria for intermediate care only.

Given this categorization, you are now asked to add, delete, or modify criteria for each category as you deem necessary. Write any corrections you may have directly on the attached sheets.

Due mainly to summer holidays, it has taken longer than expected to prepare the master sheets of your responses for Round Two. It is important that this round be carried out as soon as possible. This round should take little of your time and can be returned to me by placing the corrected sheets in the enclosed envelope.

Thank you for your continued participation.

Sincerely,

Nicole Bertinshaw

DELPHI PROCESS

Round Two

Criteria justifying assignment of an infant to each level of care are:

INTENSIVE CARE

Parenteral nutrition

Major surgery

Intrathecal drugs

Intensive lab. monitoring

Chest tube drainage

Prolonged mechanical ventilation

High oxygen therapy

Nursing care on 1:1 basis

Full-time neonatologist with 24 hr. resident coverage

Full-time resp. tech. coverage

Consultation with sub-specialties

Arterial lines

Intense phototherapy

Severe infection treatment

Intense drug therapy

Intense chest physiotherapy

INTERMEDIATE CARE

Oxygen therapy (less than 100%)

Some intravenous medications

Less major surgery

Intensive family support

Observation of high risk infants

Short-term ventilator therapy

Intravenous hyperalimentation

Blood and Exchange transfusions

Transportation facilities to tertiary center

Pediatrician coverage

...2

INTERMEDIATE CARE (cont'd)

Respiratory tech. available for coverage

Blood gases

Sepsis work-up

Arterial blood gases

Intermediate chest therapy

CONVALESCENT CARE

Gavage or gastostomy feeds

Oral or intramuscular medications

Parental teaching

Infants under observation

Routine premature care

Phototherapy

Cardiac-pulmonary monitoring

Pediatrician or general physician with interest in newborn care

Basic lab facilities

Stimulation of parent involvement

Bottle or breast feeds

Minimum chest physiotherapy

Minimum drug therapy

Referrals to community services

****

Please write any comments you may have directly on these sheets. If you agree with the lists of criteria as they are above, please check here ______

A.4 Round Three Letter and Questionnaire

September 11, 1979

Dear Delphi Participant,

Thank you for your prompt response in the second round of the delphi process. In this round, a response rate of 100% was achieved and many useful comments and corrections to the original list were presented.

You will find attached a new set of criteria which was composed by incorporating your suggestions into the original list. On the whole, your opinions as a group of varied professional backgrounds and situations were remarkably similar. There were, however, some conflicting opinions on certain items. The resolution of these conflicts consisted of choosing the the opinion for which a reasonable explanation had been provided. For example, the need for arterial lines was considered by some to indicate intensive care, and by others to indicate intermediate care. Since it was pointed out that babies with arterial lines require constant observation, this criterion was placed in the intensive level.

Please keep in mind that the definitions you are preparing are normative in nature, that is, they describe the services that each level ought to be offering, rather than what is possible or necessary under present conditions. Also remember that the definitions you develop are strictly for your own use as a group in assigning a sample of patients to the appropriate level.

If there should be any questions you would like to discuss with me, call me at 288-0266 at any time. I look forward to your responses to this third round. Thank you for the time, effort, and goodwill you are generously providing in this project.

Sincerely,

Nicole Bertinshaw

DELPHI PROCESS

Round Three

Criteria justifying assignment of an infant to each level of care are :

INTENSIVE CARE

Hyperalimentation

Major surgery

Intrathecal drugs

Intensive lab. and Xray monitoring

Prolonged mechanical ventilation

High oxygen therapy (greater than 40-60%)

Prolonged nursing care on a 1:1 basis

Full time neonatologist with 24 hour resident coverage

Full time respiratory technologist with 24 hour coverage

Consultation with pediatric and other sub-specialties

Severe infection treatment

Intense drug therapy (many and complex administration)

Arterial lines

INTERMEDIATE CARE

Oxygen therapy (less than 40-60%)

Most intravenous medications

Some major surgery

Intensive family support

Observation of high-risk infants

Short-term ventilator therapy (CPAP, CNEG, or Respirator) (in emergency)

Blood and Exchange transfusions

Pediatrician with some training in neonatal medicine and consultation with specialists

INTERMEDIATE CARE cont'd

Intravenous therapy

Respiratory tech. available for coverage

Chest tube drainage

Blood gases

Sepsis work-up and treatment

Electronic cardiac-pulmonary monitoring

CONVALESCENT CARE

Gavage or gastrostomy feeds

Oral or intramuscular medications

Parental teaching

Stimulation of parent involvement

Phototherapy

Pediatrician or general practitioner with interest in newborn

Basic lab facilities

Chest physiotherapy

Minimum drug therapy

Referrals to community services

DELPHI PROCESS

Consensus

Criteria justifying assignment of an infant to each level of care are:

INTENSIVE CARE (A)

Hyperalimentation
Major surgery
Intrathecal drugs
Intensive lab & X-ray monitoring
Prolonged mechanical ventilation
Prolonged nursing care on 1:1
Full-time neonatologist with 24 hr. resident coverage
Full-time resp. tech. with 24 hr. coverage
Consultation with pediatric and other sub-specialties
Severe infection control & treatment
Intense drug therapy (many and complex administration)

INTERMEDIATE (B)

Most intravenous medications
Some major surgery
Intensive family support
Observation of high-risk infant
Short-term ventilator therapy
Blood and exchange transfusions
Pediatrician with some experience in neonatology and consultation with specialists
Intravenous therapy
Respiratory tech. available for coverage
Chest tube drainage
Sepsis work-up and treatment
Electronic cardio-pulmonary monitoring

CONVALESCENT CARE (C)

Gavage or gastrostomy feeds
Oral or intramuscular medications
Parental teaching
Stimulation of parent involvement
Phototherapy
Pediatrician with interest in newborn
Basic lab facilities
Chest physiotherapy
Minimum drug therapy
Referrals to community services

****

Appendix B

Assessment/Classification Form used in the Study

Neonatal Intensive Care Classification Project

Patient Assessment

Sample No.______

Patient Identification - Name:______________________

Sex: M / F   Date of Birth:________________

Home Address: (city)_______________

Hospital:_________________   Crib No.____________

Assessor:_________________   Date of Assessment:______

Neonatal Intensive Care
Classification Project

SAMPLE # ________

A. Respiration

	Yes	No
1. Oxygen therapy..........	___	___
2. Ventilator care		
a) first 24 hours.....	___	___
b) after first day....	___	___
3. Intubation.............	___	___
4. Extubation.............	___	___
5. Chest physiotherapy		
a) ventilated.........	___	___
b) non-ventilated.....	___	___
6. Chest tube.............	___	___

C. Supervision and Monitoring

8. Vital signs
   - a) every 1-2 hours ___
   - b) every 3-7 hours ___
   - c) 8 or more hours ___
9. Blood pressure monitor
   - a) None ___
   - b) Arterial ___
   - c) Peripheral ___

	Yes	No
10. Cardiac monitoring	___	___
11. Cardiac-Respiratory monitoring	___	___
12. Apnea monitoring	___	___

B. Nutrition

7. Method of nutrition
   - a) Breast-feeding..... ___
   - b) Bottle-q3......... ___
   - c) Bottle-q4......... ___
   - d) Gavage............ ___
   - e) Bottle/Gavage...... ___
   - f) I.V. therapy....... ___
   - g) Continuous Drip.... ___
   - h) T.P.N. .... ___

D. Treatments

13. Environment
   - a) Radiant warmer..... ___
   - b) Isolette.......... ___
   - c) Crib.............. ___
14. Blood Transfusion
   - a) Exchange.......... ___
   - b) Plasma............ ___
   - c) Other............. ___ (Specify ________)
   - d) None.............. ___
15. Emergency surgery
   - a) None.............. ___
   - b) Minor............. ___
   - c) Major............. ___

Cont'd...

(cont'd)

Neonatal Intensive Care Classification Project

E. Medications (excluding oxygen)

Drugs needed and method of administration

	None	I.V.	Oral	Inj.	Cont. Inf.
18. Vasoactive drugs	___	___	___	___	___
19. Alkalai infusion	___	___	___	___	___
20. Recent digitalization	___	___	___	___	___
21. Recent anticonvulsants	___	___	___	___	___
22. Continuous muscle relaxants	___	___	___	___	___
23. Antibiotics	___	___	___	___	___
24. Nutritional supplements	___	___	___	___	___

F. Diagnostic Tests

25. Blood gases
    - a) None.................. ___
    - b) Capillary (4 or less) ___
    - c) Capillary (5 or more) ___
    - d) Arterial (4 or less) ___
    - e) Arterial (5 or more) ___
26. X-Rays
    - a) 0-2/day...... ___
    - b) 3 or more/day ___

	Yes	No
27. Sepsis work-up	___	___
28. Urine analysis	___	___
29. CBC	___	___
30. Bilirubin	___	___
31. Electrolytes	___	___
32. EEG/EKG	___	___
33. Other Specialized (specify ___________)	___	___

	Yes	No
16. Phototherapy..................	___	___
17. NG or OG tube................. (for drainage)	___	___

G. Parent Teaching and Support

34. Parent acceptance

    a) High ___ b) low ___ c) unknown ___

35. Parental relationship

    a) stable ___ b) unstable ___ c) unknown ___

36. Emotional support systems

    a) good ___ b) poor ___ c) unknown ___

37. Maternal experience with sick infants

    Yes ___ No ___ Unknown ___

State of infant reflecting parental needs:

38. Length of hospitalization of infant

    a) less than 3 weeks ___ b) 3 weeks or more ___

39. Period of critical illness of infant

    a) short ___ b) long ___

40. Number of set-backs to date

    a) few ___ b) many ___

41. Prognosis

    a) good ___ b) guarded ___

Appendix C

Code Values for Assessment Form

Code Values

Neonatal Intensive Care Classification Project

(only one card was necessary for each case)

COLUMN	VARIABLE	ALTERNATIVE	CODE
2-5	Patient number	random number	001-200
5	Hospital	Calgary General	1
		Foothills	2
		S.A.Grace	3
		Holy Cross	4
		Lethbridge	5
		Medicine Hat	6
6	Nursery type	intensive	1
	(by assessor judgement)	intermediate	2
		convalescent	3
7-10	Date of assessment	day/month	date
11-13	Age	days	1-120
14	Sex	female	1
		male	2
15	Size of home town	less 10,000	1
		10,000-100,000	2
		more than 100,000	3
16	Distance from home	< 50 km.	1
		50 - 200 km.	2
		> 200 km.	3
17	Multiple birth	single	1
		twin	2
18	Oxygen therapy		
19	Ventilator,1st 24 hrs.		
20	Ventilator, 24 hrs.		
21	Intubation	yes	1
22	Extubation	no	2
23	Ventilated chest physio.		
24	Nonventilated chest physio.		
25	Chest tube		

cont'd

COLUMN	VARIABLE	ALTERNATIVE	CODE
26	Vital signs	every 1-2 hrs.	1
		every 3-7 hrs.	2
		every 8 hrs. or more	3
27	Blood pressure monitor	none	1
		arterial	2
		peripheral	3
28	Cardiac monitor	yes	1
29	Cardiac-respiratory monitor	no	2
30	Apnea monitor		
31	Vasoactive drugs	none	1
		oral	2
		continuous infusion	3
32	Alkalai infusion	none	1
		intra-venous	2
		continuous infusion	3
33	Digitalization	none	1
34	Anticonvulsants	oral	2
35	Muscle relaxant	none	1
		oral	2
		injection	3
36	Antibiotics	none	1
		oral	2
		injection	3
		intra-venous	4
37	Nutritional supplements	none	1
		oral	2
		intra-venous	3
		continuous infusion	4
38	Blood gases	none	1
		capillary, 4 or less	2
		capillary, 5 or more	3
		arterial, 4 or less	4
		arterial, 5 or more	5
39	X-rays	0-2/day	1
		3 or more/day	2

Code Values (cont'd)

COLUMN	VARIABLE	ALTERNATIVE	CODE
40	Sepsis work-up		
41	Urine analysis		
42	CBC		
43	Bilirubin	yes	1
44	Electrolytes	no	2
45	EEG/EKG		
46	Non-routine biochemistry		
47	Method of nutrition	breast	1
		bottle - q3	2
		bottle - q4	3
		gavage	4
		bottle-gavage	5
		IV - therapy	6
		continuous drip	7
		TPN	8
48	Environment	radiant warmer	1
		isolette	2
		crib	3
49	Blood or other transfusion	exchange	1
		plasma	2
		other	3
		none	4
50	Emergency surgery	none	1
		minor	2
		major	3
51	Phototherapy	yes	1
52	NG or OG tube	no	2
53	Parent acceptance	high	1
		low	2
		unknown	3
54	Parental relationship	stable	1
		unstable	2
		unknown	3
55	Emotional support	good	1
		poor	2
		unknown	3

Code Values (cont'd)

COLUMN	VARIABLE	ALTERNATIVE	CODE
56	Maternal experience	yes	1
		no	2
		unknown	3
57	Length of hospitalization	less than 3 weeks	1
		3 weeks of more	2
58	Period of critical illness	short	1
		long	2
59	Number of setbacks	few	1
		many	2
60	Prognosis	good	1
		guarded	2
61	Panel classification #1		
62	" " #2		
63	" " #3		
64	" " #4		
65	" " #5	intensive	1
66	" " #6	intermediate	2
67	" " #7	convalescent	3
68	" " #8		
69	" " #9		
70	" " #10		
71	" " #11		

Appendix D

Instrument for Assessment and Classification of ICN Patients resulting from the Neonatal Intensive Care Classification Project

ICN PATIENT ASSESSMENT / CLASSIFICATION FORM

Patient Identification

Surname:________________ Sex:______ Date of Birth:___/___/____ Date of Assessment:___/___/____

Assessment Variable	Alternatives (code value)		Weight	Sub-Total
1. Oxygen therapy	No (0)	Yes (1)	x 272	______
2. Ventilator more than 24 hrs.	No (0)	Yes (1)	x 300	______
3. Nonventilated chest pysio	No (1)	Yes (0)	x 100	______
4. Vital signs	every 8 hrs. (0)	3-7 hrs. (1); 1-2 hrs. (2)	x 87	______
5. Cardiac monitor	No (0)	Yes (1)	x 245	______
6. Cardiac-respiratory monitor	No (0)	Yes (1)	x 141	______
7. Apnea monitor	No (0)	Yes (1)	x 140	______
8. Muscle relaxants	None (2)	Oral (1); Injection (0)	x 82	______
9. Antibiotics	None (0)	Oral (1); Injection (2); Intravenous (3)	x 39	______
10. Nutritional supplements	None (0)	Oral (1); Intravenous (2); Continuous Int. (3)	x 109	______
11. Method of feeding	Breast (0)	Q3 (1); Q4 (2); Gavage (3); Bot/Gavage (4); I.V. (5); Cont.drip (6); TPN (7)	x 83	______
12. Environment	Crib (0)	Isolette (1); Radiant warmer (2)	x 83	______
13. Transfusions	None (0)	Other (1); Plasma (2); Exchange (3)	x 106	______
14. Blood gases	None (4)	Cap (<5) (3); Cap (≥5) (2); Art (<5) (1); Art (≥5) (0)	x 4	______
15. Sepsis workup	No (0)	Yes (1)	x 106	______
16. Urine analysis	No (0)	Yes (1)	x 107	______
17. Prognosis	Good (0)	Guarded (1)	x 62	______

CONSTANT 546

TOTAL ...... ______

To determine classification of infant :
a) multiply the appropriate code value by corresponding weight
b) sum all sub-totals, add constant to get TOTAL
c) divide TOTAL by 1000, and round off to nearest integer; 1,2 or 3.
d) 1 indicates convalescent, 2 indicates intermediate, and 3 indicates intensive care.

TOTAL/1000 = Level of Care
1=Convalescent
2=Intermediate
3=Intensive

Note that weights on this form differ from those developed in text. This is due to the rearrangement of code values and the reassignement of values to the different levels.